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# Bulletin

*of the*

# Torrey Botanical Club

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BULLETIN OF THE TORREY BOTANICAL CLUB
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# THE EPIPHYLLOUS FLOWERS OF TURNERA AND HELWINGIA

MARION A. JOHNSON

On a recent collecting trip in Puerto Rico, my attention was called to the conspicuous epiphyllous flowers of *Turnera ulmifolia* L. by Professor R. O. Woodbury of the Agricultural Experiment Station, Rio Piedras. This species is a shrub native to the West Indies, Mexico, Central and South America, and is frequently cultivated as an ornamental for its showy yellow flowers which are borne high on the petiole (fig. 22).

The Turneraceae is a favorable family in which to study the evolution of the epiphyllous habit; according to Urban (1883) four genera, *Wormskioldia*, *Streptopetalum*, *Periqueta* and *Mathurina* have axillary inflorescences, and the remaining genus, *Turnera*, has the peduncle more or less adnate to the subtending leaf. *Turnera ulmifolia* is an especially favorable subject for study since it blossoms throughout the year, may be propagated readily from seed or cuttings, begins to flower at an early age —often on the 12th leaf above the cotyledons, and in northern climates is an excellent greenhouse plant. The report presented here is based largely, therefore, upon *T. ulmifolia* although reference is made to other epiphyllous species where pertinent.

Morphologists have devoted so little attention to epiphyllous flowering that scant reference can be found to this striking phenomenon in modern textbooks. The epiphyllous habit appears to be widely scattered and, while noted by taxonomists, has generally been treated as a minor characteristic, as a consequence, difficulty is experienced in determining its range of occurence in the angiosperms as a group. The list of species which follows (Table 1) has been compiled from the works of Payer (1852), Clark (1883), Boldt (1897), DeCandolle (1890), Gilg (1925), Engler (1931), Stork (1956), and the material from which this study was made. This list is undoubtedly incomplete, but probably gives a general idea of the distribution of epiphylly in angiosperms and also suggests that leaf-borne flowers are found more frequently in the tropics and subtropics than in the temperate zones.

Epiphyllous flowers may be borne at almost any level on the petiole or midvein of the blade, either singly, or in few to many-flowered inflorescences. Some of the more frequently illustrated species showing position on the blade are: *Phyllobotryum spathulatum* (Gilg 1925)—in a number of "grape-like" clusters on the midrib near the axils of the lateral veins; *Phyllonoma ruscifolia* (Stork 1956)—in a cyme immediately



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beneath the attenuate tip; *Helwingia japonica* (DeCandolle 1890)—in a fascicle below or near the middle of the blade; *Streptocarpus wendlandii* (Bailey 1900)—in several paniculate racemes arising from the base of the blade; and *Phylloclinium paradoxum* (Gilg 1925)—with a single flower near the middle of the blade. Similar variation exists in position on the petiole: *Chirita hamosa* (Boldt 1897) bears a file of six or more flowers extending throughout the length of the petiole; *Tapura capitulifera* (Stork 1956) has a pair of head-like inflorescences on opposite sides of the petiole near the distal end; *Dichapetalum spruceanum* (Stork 1956) bears a pair

TABLE 1. *Species having epiphyllous flowers; tropical and subtropical species are marked with an asterisk*.*

BEGONIACEAE
*Begonia prolifera* A. DC.*
*Begonia sinuata* Wall.*

CELASTRACEAE
*Polycardia hilbrandtii* Baill.*
*Polycardia phyllanthoides* Lam.*

CORNACEAE
*Helwingia chinensis* Batal.
*Helwingia japonica* (Thunb.) Dietr.

DICHAPETALACEAE
*Dichapetalum pendunculatum* Baill.*
*Dichapetalum spruceanum* Baill.*
*Gonypetalum tessmannii* Krause*
*Tapura capitulifera* Baill.*

FALCOURTIACEAE
*Phyllobotryum basiflorum* Gilg.*
*Phyllobotryum spathulatum* Muell.*
*Phyllobotryum zenkeri* Gilg.*
*Phylloclinium bracteatum* Lacomte*
*Phylloclinium paradoxum* Baill.*
*Macquerysia multiflora* Hua*

GESNERACEAE
*Acanthonema strigosum* Hook.*
*Chirita hamosa* R. Br.*
*Didymocarpus pygmaea* C. B. Clarke*
*Epithema horsfieldii* R. Br.*
*Platystemma violoides* Wall.*
*Streptocarpus dunnii* Hook.*
*Streptocarpus galpini* Hook.*
*Streptocarpus polyanthus* Hook.*
*Streptocarpus saundersii* Hook.*
*Streptocarpus wendlandii* Dammann*

ICACINACEAE
*Leptaulus daphnoides* Benth.*

PIPERACEAE
*Peperomia foliflora* Ruiz and Pav.*
*Peperomia haenkeana* Opiz*

RUTACEAE
*Erythrochiton hypophyllanthus* Planch. and Linden*

SAXIFRAGACEAE
*Phyllonoma integerrina* Turez.*
*Phyllonoma latiscuspis* Turez.*
*Phyllonoma ruscifolia* Willd.*

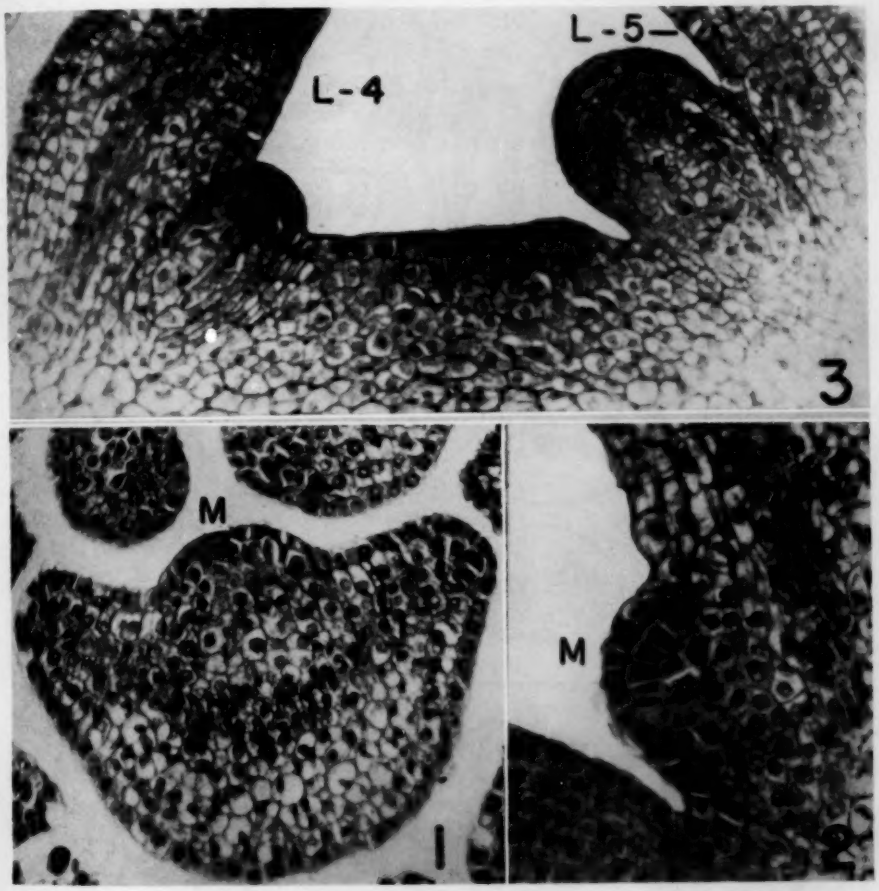
TURNERACEAE
*Periqueta cistoides* (L) Meyer*
*Periqueta tomentosa* H.B.K.*
*Turnera aphrodisiaca* Ward*
*Turnera diffusa* Willd.*
*Turnera hassleriana* Urb.*
*Turnera melochioides* Camb.*
*Turnera mollis* H.B.K.*
*Turnera odorata* Rich.*
*Turnera pinnatifida* Juss.*
*Turnera pumilea* L.*
*Turnera ulmifolia* L.*
*Turnera weddelliana* Urb. and Rolfe*

of highly branched inflorescences above the middle of the petiole; and *Turnera* in which a single flower may be borne basipetally (*T. odorata*) or distally on the petiole (*T. ulmifolia*).

Perhaps the most remarkable case of epiphyllous flowering, and one not widely cited in the literature, is that of the South American *Erythrochiton hypophyllanthus* in which, as the specific epithet suggests the flower is borne on the lower surface of the leaf (Engler, 1931).

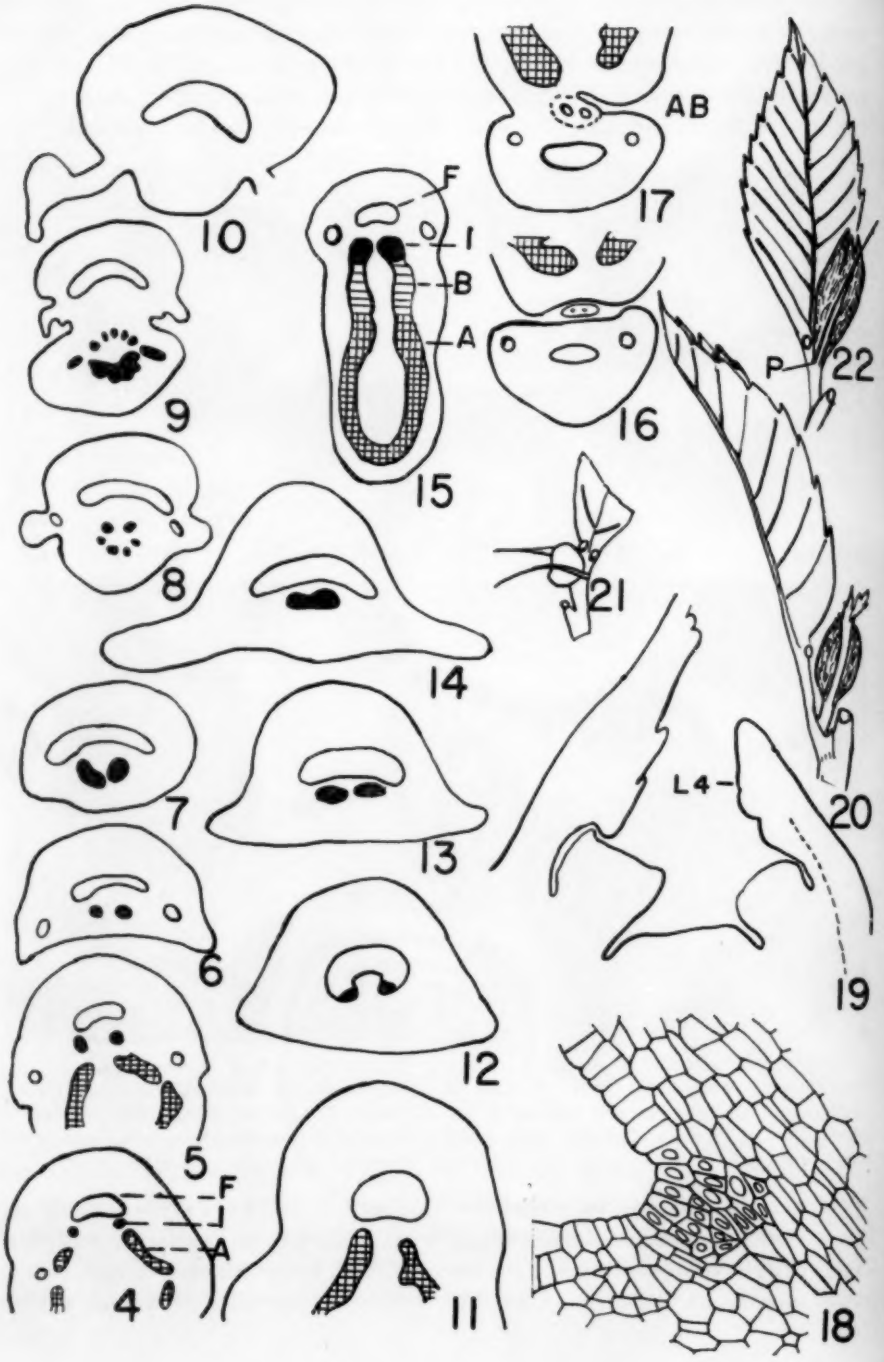
Epiphyllous flowers are probably considered to be a novelty by most botanists with the primary interest centering about mode of origin. Three

species have been critically investigated: *Helwingia japonica* DeCandolle, 1890), *Chirita hamosa* (Boldt, 1897), and *Phyllonoma ruscifolia* (Stork, 1956). The inflorescence meristems are axillary in origin in *Chirita* and foliar in *Helwingia* and *Phyllonoma*, however, subsequent growth makes the determination of origin from external characteristics impossible.




FIGS. 1–3. *Helwingia japonica.* FIG. 1. Transverse section through leaf 5 from apex showing early stage in development of inflorescence meristem, M, on adaxial face. ×200. FIG. 2. Inflorescence meristem, M, as seen in longitudinal section of leaf 4. ×300. FIG. 3. *Turnera ulmifolia*, near median longitudinal section through apex showing fertile leaves, L-4 and L-5, with inflorescence primorida in axillary position. ×200.

**Materials and methods.** Branch tips and leaves of *Turnera ulmifolia* L., in various stages of development, were collected in the vicinity of San Juan, Puerto Rico, during the summer of 1956. Seeds planted under greenhouse conditions germinated readily and soon provided flowering speci-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mens. Comparable collections of *Helwingia japonica* (Thunb.) Deitr. were procured from the Arnold Arboretum.[1] All material was fixed in formalin-acetic acid-alcohol and processed for histological study. A gross anatomical study was made of the following species from herbarium material:[2] *Turnera actua* Willd., *T. aphrodisica* Ward., *T. diffusa* Willd., *T. glabrescens* Small., *T. hassleriana* Urb., *T. melochioides* Camb., *T. mollis* H.B.K., *T. odorata* Rich., *T. ovata* Urb., *T. pinnatifida* Juss., *T. pumilea* L., *T. weddelliana* Urb. and Rolfe, *T. whitei* Rusby, *Periqueta caroliniana* (Walt.) Urb., *P. cistoides* (L.) Meyer, and *P. tomentosa* H.B.K. Dried twigs and leaves were soaked for several days in glycerin-alcohol (1 part glycerin to 9 parts 60% alcohol), softened with hydroflouric acid, and processed according to standard histological techniques.

**Results. Turnera.** The leaf primordia in *T. ulmifolia* arise from a low, broad, plateau-shaped shoot apex. The inflorescence primordium can be recognized first, as a group of meristematic cells, in the axil of the second leaf primordium (L-2) from the apex (fig. 18). A conspicuous shell zone developes in the axil and the meristem becomes isolated from the procambium of the axis and also from that of the leaf primordium by vacuolating cells. There is a single tunica layer during early stages in the organization of this meristem, but stratification eventually extends to the sub-surface cells producing a second tunica layer as is seen in the shoot apex of the axis. The inflorescence meristem associated with L-3 or L-4 projects into the leaf axil (fig. 3). Beyond this stage, the inflorescence primordium is elevated by pronounced growth in the foliar buttress. The axillary origin of the inflorescence, together with growth of the foliar buttress, are the basic morphological features in the development of the epiphyllous habit of flowering in *Turnera ulmifolia*.

[1] Through the courtesy of the Director.

[2] Secured through the courtesy of the Director of the New York Botanical Garden.

FIGS. 4–22. FIGS. 4–10. *Turnera ulmifolia*. Series of diagrams illustrating vascular anatomy of fertile leaf from level of foliar gap into level of leaf blade; vascular supply of axis is crosshatched (A), of inflorescence is in solid black (I), and of leaf is unshaded (F). ×19. FIG. 9 is at level of prophyll node (P) in figure 22. FIGS. 11–14. *Helwingia japonica*. Series of diagrams illustrating vascular anatomy of fertile leaf, shading as in figs. 4–10; note that the vascular supply to the inflorescence and the median foliar bundle are confluent in the petiole (fig. 12) while in *T. ulmifolia* the inflorescence traces occupy the position of a vegetative branch (figs. 4, 5). ×37. FIG. 15. *T. ulmifolia*. Cross section at node showing vascular connection of inflorescence and vegetative branch with axis; branch traces ruled with parallel lines (B), otherwise shading as in figs. 4–10. ×7. FIGS. 16, 17. *T. ulmifolia*. Showing position of vegetative bud, AB, in relation to the main axis and subtending leaf. ×45. FIG. 18. *T. ulmifolia*. Inflorescence meristem in axil of leaf 2. ×310. FIG. 19. *T. ulmifolia*. Inflorescence primordia in axils of leaves 4 and 5. ×80. FIG. 20. *T. odorata*. Fertile leaf showing position of flower bud. ×4. FIGS. 21, 22. *T. ulmifolia*. Fertile leaves showing position of fruit and flower bud respectively. ×1.

For ease in description, petioles bearing flowers will be referred to hereafter as 'fertile' and those without flowers as 'sterile'.

Since the inflorescence proved to be axillary in origin, a study was made of its vascular supply for comparison with that of a vegetative branch. The vascular pattern of a young fertile petiole is shown in figures 4 to 10. The vascular system of the axis is cross-hatched, that of the petiole proper is shaded, and that of the inflorescence is in solid black. It is at once apparent that the vascular connection between the inflorescence and the main axis, and it should be recalled that the inflorescence in *Turnera ulmifolia* is located high on the fertile petiole, *is similar* to that of a vegetative branch with two branch traces. The foliar gap is trilacunar with the median gap serving as a common gap for the midtrace of the leaf and the inflorescence traces. A noteworthy feature is that the foliar and inflorescence traces remain distinct; the fertile petiole accordingly may be thought of as possessing a double structure, or it possibly may be considered as a concrescence although there is no evidence whatsoever of actual fusion between the axillary meristem and the base of the leaf primordium, rather this becomes a striking example of displacement through growth in the foliar buttress.

The foliar gap of the sterile leaf is also trilacunate, the midtrace is well developed, but the two laterals are relatively weak (fig. 16). Vascular connection between the branch and the main axis is through two branch traces, and again the median foliar gap and branch gap are continuous. The particularly noteworthy feature here is that intercalary growth in the development of the sterile leaf is confined almost exclusively to the base of the leaf primordium above the leaf axil. Consequently, the vegetative branch is not displaced but retains its strictly axillary position, although there is a tendency for the branch to be attached to the petiole at a slightly higher level than to the axis (fig. 17).

Vegetative branches arise in the axil of the fertile petiole in the same manner that the inflorescence meristem originates in the axil of the leaf primordium. Inception of the branch primordium, however, occurs later; the earliest in my material was first recognizable in the axil of fertile leaf 5. Four plastochrones later, the bud meristem projected into the axil (L-9). There seems to be a tendency to delay growth of the vegetative meristem even further in young vigorous plants. In one such instance the 31st fertile leaf was the first to have a bud meristem projecting above the surface of the axil.

A detailed study of floral development was not attempted although it is clear that floral development is precocious when compared to that of the vegetative branches. The inflorescence meristem is generally initiated in the axil of L-2 (fig. 18), and during the next two plastochrones is elevated

above the shoot apex (axil of L-4 in figures 3, 19). During the two subsequent plastochrones, prophyll primordia, and five sepal primordia become discrete. Thus, during five plastochrones the inflorescence develops to a stage consisting of a short axis, two prophyll primordia, five sepal primordia, and the remainder of the floral apex from which petal, stamen, and carpel primordia will be initiated. Vascularization of the flower is in accord with the account given by Rao (1949).

*Turnera* is a relatively large genus, Urban (1883) recognized 57 species, and a number of new species have been described since that time. Material was not available for exploring the entire genus. However, an examination was made of the specimens in the herbarium of the New York Botanical Garden; certain species were clearly epiphyllous, others had axillary inflorescences, while still others bore flowers so near the axil of the subtending leaf that sections were necessary for reliable determination. Eight species: *T. aphrodisiaca*, *T. diffusa*, *T. hassleriana*, *T. melochioides*, *T. mollis*, *T. odorata*, *T. pinnatifida*, and *T. weddelliana* have fertile leaves with a vascular pattern similar to that of *T. ulmifolia*. These are distributed in five of the nine sections into which Urban subdivided the genus. Three species: *T. acuta*, *T. glabrescens*, and *T. whitei* have axillary inflorescences with the vascular attachment to the axis similar to that of a vegetative branch; other species appeared to have axillary inflorescences but material could not be made available for anatomical study. Perhaps a future monographer will find the epiphyllous habit of flowering a useful characteristic in his treatment of the genus.

A few herbarium specimens were examined from the allied genus *Periqueta;* here also, axillary and epiphyllous inflorescences were found —*P. ovata* and *P. caroliniana* are axillary and *P. cistoides* and *P. tomentosa* are epiphyllous. Sufficient material was not available for determining the proportion between axillary and epiphyllous inflorescences in the genus. The need for further anatomical investigation in this genus is suggested in the light of these findings, and by Urban's (1883) statement that in *Periqueta* the peduncle is always free from the petiole.

**Helwingia.** DeCandolle (1890) contrary to the observations of Payer (1852), came to the conclusion that the epiphyllous inflorescence of *Helwingia* arose from the adaxial face of the leaf primordium. This was readily verified in my material of *H. japonica*, and in addition, it was found that L-4, L-5, and L-6 were critical for locating the initiating stages. The account which follows is from observations made on a branchlet with flowers in several phases of development. Leaf primordia arise in spiral sequence from the shoot apex and are essentially similar to those generally reported for dicotyledons with the possible exception that adaxial vacuolation is somewhat delayed at the base of the primordium. This region is the seat

of an adaxial meristem some six cells in width from which the inflorescence primordium is elevated (fig. 1). Specifically, leaves one to five of the branchlet were 20, 120, 240, 550, and 710 $\mu$ in height respectively; L-2 was the first to show abaxial vacuolation and L-3 the first with adaxial vacuolation although it was confined to the distal part of the primordium, L-4 was conspicuous for the adaxial meristem, and L-5 for a clearly delimited inflorescence meristem (fig. 1). Instances were found where the inflorescence primordium had been initiated on L-4, such a case is illustrated in figure 2. the leaf primordium measured 305 $\mu$ in height.

The vascular pattern in a young fertile leaf of *Helwingia japonica* is quite distinct from that of *Turnera ulmifolia* as may be seen by comparing figures 4–10 with figures 11–14; in each instance, the vascular supply to the inflorescence is shown in solid black. It will be noted that in *Turnera* the inflorescence traces connect with the stele of the main axis as in a vegetative branch, while in *Helwingia* the connection is with the midvein of the leaf.

A vegetative bud in *Helwingia* can first be detected as a detached meristem in the axil of the fourth or fifth leaf from the apex. These meristems are better developed on the petiole side of the axis and, as a consequence, the young bud is attached to the base of the petiole for a short distance; in no instance, however, has a bud been found to occupy a petiolar position comparable to an epiphyllous inflorescence.

**Discussion.** The epiphyllous habit of flowering in the genus, *Turnera*, is undoubtedly a derived characteristic. This view is supported by the fact that the inflorescence meristem in *T. ulmifolia* originates in a strictly axillary position and in precisely the same manner that vegetative buds arise in the axil of sterile leaves. Moreover, the vascular connection with the axis is identical with that of a vegetative bud. Also, the genus contains species in which the inflorescence remains in the axil of the subtending leaf and the vascular attachment, as would be expected, is that of a vegetative branch. It seems reasonable, therefore, to interpret epiphylly in this genus as having been derived both ontogenetically and phylogenetically from the axillary position.

A somewhat similar condition exists in *Chirita hamosa* (Boldt 1897); here also, an inflorescence meristem originates in the axillary position and through intercalary growth is displaced into a petiolar position. In this species a series of inflorescence meristems arise *abaxially* to the first one. Vascular attachment between the primary inflorescence and the axis is similar to that of a vegetative branch. The vascular supply of the oldest secondary inflorescence, however, is attached to that of the primary inflorescence and likewise, that of each successive inflorescence is attached to the supply of the inflorescence preceding it.

The epiphyllous condition is more complex in *Helwingia japonica* and *Phyllonoma ruscifolia* than in *Turnera* or *Chirita*. The inflorescences are displaced by intercalary growth, but differ from *Turnera* and *Chirita* in that they originate from the adaxial face of the fertile leaf and not in the leaf axil. The vascular attachment of the inflorescence reflects the foliar origin, for in both *Phyllonoma* (Stork 1956) and in *Helwingia*, it is with the midvein of the fertile leaf and not with the axis proper. *Phyllonoma* and *Helwingia* are relatively small genera and are completely lacking in members with axillary inflorescences.

DeCandolle (1890) contended that the vascular pattern of the fertile petiole reflected the origin of the epiphyllous inflorescence; attachment to the midvein of the fertile leaf indicating foliar origin while attachment to the axis in the manner of a vegetative bud was proof of axillary origin. Actually the precise origin of the epiphyllous habit is known in only four species: *Helwingia japonica, Phyllonoma rusciflora, Chirita hamosa,* and *Turnera ulmifolia*. DeCandolle's view is supported in each of these; the inflorescence is foliar in origin in *Phyllonoma* and *Helwingia* and the vascular attachment is with the midvein of the fertile leaf, while it is axillary in *Turnera* and *Chirita* and the vascular attachment is with the main axis. Evidence from four genera may be too limited for broad generalization, as further histological study may prove; this character, if shown to be reliable, would be extremely valuable in predicting origin of the epiphyllous habit of tropical and sub-tropical material where one must often be limited, of necessity, to herbarium specimens.

Angiosperms with the epiphyllous habit of flowering present many problems to those interested in growth and development, likewise they offer an almost unequalled source of material for growth studies. Extensive studies in the morphogenesis of the angiosperm leaf show that the foliar buttress and tip of the leaf primordium, as a rule, mature early in the development of the leaf. Consequently intercalary growth is largely responsible for the major part of the mature leaf. Growth zones and their contribution to area and shape of the leaf have been discovered by morphological study of large series of killed and fixed material. More direct evidence has been obtained by the familiar method of marking young leaves with various grid patterns which graphically reflect growth changes during the development of an individual leaf. The former method is open to the criticism that a composite picture of growth from many leaves is obtained rather than for a single individual; in the latter method, grids can not be marked upon leaf primordia because of their small size. *Turnera ulmifolia* is as suitable for both of these methods as other plants, and, in addition, possesses the merit of having a natural growth marker in the epiphyllous inflorescence. The fertile petiole, to the level of the inflorescence, clearly has been pro-

duced from growth in the foliar buttress below the cite of origin of the inflorescence meristem. Ordinarily the foliar buttress is the first part of the leaf primordium to mature, but apparently this can not be the case in epiphyllous species where the inflorescence primordium arises in the axillary position.

Likewise, in *Helwingia japonica*, using the inflorescence meristem as a growth marker, all of the petiole and perhaps as much as ¼ to ½ of the blade is produced by intercalary growth in the primordium beneath the level of the inflorescence meristem—a zone 50 $\mu$ or less in height. The foliar buttress cannot be involved to the extent here as in *Turnera ulmifolia* for the vegetative bud meristem, while present in the axil of the fertile leaf before growth has progressed, is not displaced. Again, another example may be had from *Phyllonoma ruscifolia* where over ¾ of the mature leaf is developed from a limited zone at the base of the leaf primordium; according to Stork (1956) the inflorescence can first be detected about 2 mm. above the axil on the adaxial face of a leaf primordium 4 mm. in height.

The recent revival of interest in the origin and differentiation of buds must be extended greatly before the degree of constancy in origin can be known in dicotyledons (Majumdar and Datta 1946, Esau 1953). Degree of constancy is particularly important since the organization of a meristematic center undoubtedly reflects activity resulting from a whole nexus of physiological processes. Thus in terms of physiological processes and their spatial delimitation in the plant, how is it possible to obtain axillary inflorescences and branch meristems in *Turnera*, but foliar inflorescence primordia and axillary branch primordia in *Helwingia*? Or how is the observation to be interpreted that growth of the petiole includes the foliar buttress in some species of *Turnera* but not in others and that the foliar buttress contributes much to the development to the fertile petiole in *T. ulmifolia* but not to the same extent to the sterile petiole? Certain experimental work, now in progress with *T. ulmofolia*, may possibly throw some light on these problems.

## SUMMARY

1. The epiphyllous inflorescence in *Turnera ulmifolia* is axillary in origin and through subsequent growth in the foliar buttress is displaced to a petiolar position. Vascular attachment between the inflorescence and the main axis is through two traces and is similar to that between a branch and the main axis. The presence of inflorescence and foliar traces in the base of the fertile petiole is considered cogent evidence for interpreting the inflorescence primordium as axillary in origin. If this be accepted as valid, 10 out of 13 species of *Turnera* examined have epiphyllous inflorescences which originated in the axil of a foliar primordium.

2. The foliar origin of the epiphyllous inflorescence reported by DeCandolle for *Helwingia* is confirmed in *H. japonica*.

3. The primordia of epiphyllous inflorescences are considered to be excellent growth markers.

4. Species having epiphyllous flowers are of more frequent occurrence in tropical and subtropical floras than in temperate floras. A family (Turneraceae, for example) may have genera in which the inflorescence in all the species maintain the axillary position at maturity (*Wormskoldia*, *Streptopetalum*, and *Mathurina*) and in addition may have genera (*Periqueta* and *Turnera*) with both axillary and epiphyllous species, or all the species in a genus may be epiphyllous (*Helwingia* in the Cornaceae).

Department of Botany
Rutgers—The State University of New Jersey.

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# STUDIES ON SECOTIACEOUS FUNGI III. THE GENUS WERAROA

ROLF SINGER AND ALEXANDER H. SMITH[1]

The genus *Weraroa* was described by Singer (1958) on one species, *Secotium novae-zelandiae* Cunn. Although distinctly a Gastromycete, it shows strong similarity with the Strophariaceae of the Agaricales, especially *Psilocybe*. The spore color, the bluing or greening of the peridium, and the anatomical features, except for the more typically gastroid spores, are all indicative in this relationship. The discovery of this striking affinity was interesting inasmuch as it was made subsequent to a monographic study of the section *Caerulescentes* of *Psilocybe* by Singer and Smith (1958).

At the time *Weraroa* was described, we were not aware that two other species, both likewise from New Zealand, should be considered congeneric. These are *Secotium virescens* Mass. and *Secotium erythrocephalum* Tulasne. True, the latter species had been studied by Heim but his observations dealt almost exclusively with the spores, and thus the relationship of this fungus with the Strophariaceae remained obscure.

A critical study of both these species reveals that the peridial structure closely resembles the structure of the upper layers of the pileus of certain members of the Strophariaceae, especially *Naematoloma*, whereas the spore color in KOH and $NH_4OH$ is more like that of *Agrocybe aegerita*, a characteristic of many members of the strophariaceous genera, especially of *Pholiota* and *Kuehneromyces*. *S. erythrocephalum* has an almost pseudoparenchymatic layer underneath the gelatinized outermost layer of the peridium. This gelatinous layer corresponds to the pellicle type of epicutis of many Strophariaceae. The subpseudoparenchymatic layer is a cutis of short, inflated hyphal cells, running parallel with the surface of the peridium and with each other, and corresponds closely with a similar layer, the hypodermium of *Naematoloma*. *S. virescens* possesses chrysocystidia in the hymenium of the loculi, and this, in addition to the truncate spores, links this fungus with *Naematoloma*, *Pholiota*, and *Stropharia*. In addition to the chrysocystidia of the hymenium, somewhat similar cells are found in the cutis-like structure of the peridium and tramal plates. We believe them to be homologous with the chrysocystidia but they differ in the appearance of their contents as revived in KOH; they are also somewhat narrower and do not form part of a palisade. Their content is deep yellow in KOH and $NH_4OH$ and they are morphologically differentiated from

[1] Papers from the University of Michigan Herbarium and the Department of Botany, no. 1076 University of Michigan, Ann Arbor, Michigan.

the other hyphae to the point of being somewhat fusoid-ventricose to nearly ellipsoid. They are apparently always terminal on hyphal filaments.

There appears to be no proper term for cystidium-like cells within the tramal tissue. We here propose to call such structures *endocystidia*. The "internal setae" in some polypores would not necessarily come under this heading since the latter are dark- and thick-walled structures, but they might be called endocystidia as long as the position rather than the structure, chemistry and physiology of the cystidioid body is considered. The term endocystidia in the narrower sense refers to the modified type of tramal chrysocystidium as described here. But in a wider sense it is the last of a series of cystidia and organs homologous with cystidia named for their position on the fruiting body. The term pleurocystidia, or cystidia in the narrower sense, applies to such cells in the hymenium on the face of the hymenophore and thus coincides with the original definition of the word cystidia. The term cheilocystidia designates the cystidioid (homologous with cystidia or similar to cystidia) bodies of the hymenophoral edges (edges of lamellae, pores, tips of teeth or spines). The term pilocystidia applies to cystidioid bodies on the surface of the pileus; caulocystidia are on the surface of the stipe. Contemplating the difficulties arising when and where there is a peridium rather than a pileus or a pileus confluent with a stipe, many authors prefere, instead of both pilo- and caulocystidia, the term dermatocystidia, designating those cystidioid bodies which are found on the sterile surfaces of any carpophore. Kühner (1946) discovered mycelial cystidia which he has termed allocysts. These, incidentally, were demonstrated by Kühner on a strophariaceous agaric along with other basidiomycetous material. The last theoretically possible type in this series is the endocystidium.

The origin of the endocystidia in *S. erythrocephalum* is obscure. Since Cunningham indicated that the young carpophores are pruinose at first, we checked on the reason for this phenomenon and found the youngest of the carpophores available to have over the peridial surface numerous dermatocystidiaer (or as they might perhaps be called, considering the homology existing between pileus and peridium in this case, pilocystidia). These were quite similar in aspect to the endocystidia of later stages.

Although, according to the data found on the respective labels and the original descriptions and notes by Cunningham, the specimens involved grew principally in the Nothofagus area, these species do not seem to be necessarily linked biologically to Nothofagus. At this time no comment on the area occupied by Weraroa is appropriate, but so far it is known only from New Zealand.

As for the generic name, it is most unfortunate that eminent mycologists like Heim when publishing on new taxa do not always observe the

universally accepted procedure for effective and valid publication. As it is, his "coupure" *Cytophyllopsis* has no standing under the rules of nomenclature accepted in Stockholm and Paris.

WERAROA Sing., Mycologia **50**: 262–303. 1958, emend. *Cytophyllopsis* Heim, Rev. de Mycol. 16: 136. 1951. *nom. nudum.*

Peridium varying from acutely fusoid to hemispheric or depressed-globose, often obovate to ellipsoid or ovate to ellipsoid, glutinous at maturity, with a number of bright pigments developing simultaneously or in succession, medium sized and never particularly narrow.

Gleba of the hymenogastraceous type consisting of loculi which are often elongated but never truly lamellate, ochraceous brown to ferrugineous or sepia to chocolate-brown, more dingy when dried.

Stipe always present, viscid or not, continuous with a columella which reaches the upper portion of the peridium and merges with it, often with veil-like structures which connect the margin of the peridium in its lower portion with the apex of the stipe; volva none.

Context fleshy, not membranous-dry, thin in the peridium, tending to be slightly to distinctly gelatinous in the tramal plates and outer portion of peridium.

Spores always rather large (about 10–20 $\mu$, exceptionally perhaps 25 $\mu$ long) but variable in size, usually ellipsoid, smooth, with a broad germ pore, axially symmetric or nearly so, pigmented ochraceous to sepia-brown (episporium usually deep red-brown); basidia typically gastroid in sterigma-production, sometimes characteristically narrower or constricted in the middle, broadest at base, usually 4-spored; chrysocystidia present in the hymenium, on sterile surfaces of young specimens, and as endocystidia; peridium with a pellicle-like outermost layer which consists of repent, thin-filamentous, hyaline, smooth and strongly gelatinized hyphae, and some gelatinization also noticeable on the tramal plates; layer underneath the gelatinized pellicle consisting of more or less swollen voluminous elements forming repent chains of cells resembling the hypodermium of *Naematoloma;* all tissues with clamp connections on the hyphae.

Habitat in the rain forest, epigeous or often epixylous.

Type species: *Secotium novae-zelandiae* Cunningham.

As Heim (1951) has correctly stated, this genus is close not only to certain Agaricales, but to the genus *Galeropsis* of the Secotiaceae in the Gastromycetes. This relationship is based on the broad germ pore of the basidiospores in both genera. The spore color is identical in some species of *Weraroa* and some species of *Galeropsis*. However, there are colors not observed in any *Galeropsis* but observed in *Weraroa* (e.gr. *Weraroa novae-zelandiae*) and there are spore colors observed in *Galeropsis* which are much more ferruginous than ever found to be in *Weraroa*. This ferruginous spore color, added to the other characters of the *Galeropsis* spores, has led mycologists to compare them with the spores of the genus with which they are most strikingly similar: *Conocybe*. For this reason, the genus was at first named *Galeropsis*, and for this reason it was later described as a subgenus of *Conocybe* by Heim. While it is true that the lack of a cellular or

hymenial layer on the peridium removes the genus *Galeropsis* somewhat from the Bolbitiaceae (to which *Conocybe* belongs), and places it in the neighborhood of the Strophariaceae, the habit and habitat of *Galeropsis*—which reminds one of *Conocybe* and *Pholiotina,* together with the spore color of some of the most important species—have caused the majority of the authors interested in these fungi to place them near the Bolbitiaceae. Although it might be argued that a cellular hymeniform outer peridial layer is hardly to be expected in a xerophytic Gastromycete, and would have developed "later" or "earlier" on the agaric-level, one should not entirely lose sight of the fact that *Galeropsis* may very well be intermediate between a hypothetical extension of the characters of the Strophariaceae and of the Bolbitiaceae as projected into the level of the Gastromycetes. In other words, it is not theoretically necessary that *Galeropsis* be exclusively similar to a single agaric family, and being also close to or at least comparable with gastroid Strophariaceae-like genera, viz. with *Weraroa,* we have to deal with the taxonomic relation between the two genera. As a matter of fact, if one were to judge by the spore structure alone, *Weraroa* would be synonymous with *Galeropsis.*

Heim (1951) thinks that the two genera (his *Cytophyllopsis* and *Galeropsis*) are easily distinguishable because *Galeropsis* has, allegedly, agaricoid spores and basidia. This, as has been shown recently by Singer (1956) is not always correct since *Galeropsis,* in this regard, is much more variable than *Weraroa,* and species in which the majority of the spores are symmetrical and formed on straight, typically gastroid sterigmata are existent and demonstrably very close to species where the spore formation is more agaricoid. The variability of the spores is such that in some species, e.gr. *G. allosperma,* the germ pore is still unevolved.

Much sharper and more generally applicable differences between *Galeropsis* and *Weraroa* than provided by spore color or spore and basidial shape, are provided by (1) consistency (2) pigmentation (3) configuration of the hymenophore (gleba), (4) habit (5) habitat. In *Weraroa* the context is consistently fleshy and soft, and not so thin as in *Galeropsis* where the consistency is markedly dry-toughish. This conforms with the fact that all species of *Weraroa* are elements of the wet rain forest and are humigenous and epixylous, while *Galeropsis* is a typically xerophytic genus, and all species, even those that fruit—during the rainiest time of the year at the edge of the water and among scattered trees of a rather dry mountain forest—are at least subxerophytic. In addition, the species of *Weraroa* tend to be strikingly bright colored, bright red, bright green or blue, or, if bluish gray at first, they tend to become green or blue. This is in contrast to the dull and banal ochre-tan color of the species of *Galeropsis.* The habit is also so different that it would be unnecessary to mention it were it

not for *W. virescens*, which has a fusoid acute peridium. Nevertheless, even in the case of this latter species, the peridium is relatively broader, and the stipe relatively less developed and not so thin as in *Galeropsis*. Altogether, the habit still makes it possible to differentiate in the field between any species of *Galeropsis* and any species of *Weraroa*, even if they should ever be found in the same area. Geographically, *Galeropsis* differs from *Weraroa* as strongly as most xerophytic genera would differ from typical rain forest genera: *Weraroa*—even if it might be assumed that some day its area will be extended by new finds—has a restricted and well defined area. *Galeropsis* is widely distributed over all hot to cold xerophytic areas of the earth.

Furthermore, the hymenophore is definitely lamellate in *Galeropsis* even where the lamellae are connected with oblique anastomoses. This leaves the main lamellae running vertically and maintaining a vertical position. In *W. novae-zelandiae* where the gleba is sometimes sublamellate, there are no strictly vertically arranged main lamellae, and the broadest tramal plates are considerably broader than the lamellae of any *Galeropsis*.

It has been argued that most of the known agaric-like Gastromycetes are merely xerophytic adaptations of individual agarics. This thesis had already been shattered by the discovery of *Thaxterogaster*, but it was revived by Heim (1951) who stated that the adaptation could be either xerophytic or hypogeous. In the case of *Weraroa*, however, there is no trace of xerophytic adaptation, and there is likewise neither hypo- nor subhypogeous development. This is accentuated by the observation that a majority of the species occur on wood.

KEY TO SPECIES

A. Gleba chocolate or sepia-brown when fresh; peridium French gray, staining blue or green ..... 1. *W. novae-zelandiae*
A. Gleba ferruginous or ochraceous when fresh; peridium not colored as indicated above ..... B
B. Peridium bright red, globose-depressed to ovoid. ..... 2. *W. erythrocephala*
B. Peridium azure blue, sage green, or sea green, conic to fusoid. ... 3. *W. virescens*

1. WERAROA NOVEA-ZELANDIAE (Cunningham) Sing. Mycologia: in press. 1958. *Secotium novae-zelandiae* Cunningham, Proc. Linn. Soc. N.S. Wales **49**: 107. 1924. Figs. 4–5. Cystidia, basidium, and spores.

Gastrocarp 30–50 mm. tall, 10–30 mm. broad, obovate or ellipsoid, apex varying from obtuse to acuminate, basal margin rounded or truncate or decurrent on stipe; peridium ½–1 mm. thick, commonly French gray changing to pallid green or bluish green, drying dingy brown, at first finely fibrillose, fibrils longitudinally arranged and surface appearing striate, becoming smooth, glabrous, polished and viscid, margin folded and frequently lacerated.

Gleba coarsely loculate, the chambers often elongate (up to 10 mm. long), chocolate to sepia-brown when fresh, dried between "Prout's brown" and "mummy brown" (R.) or *biskra, date* (M & P, 2nd ed.).

Stipe up to 40 × 7 mm., pallid French gray or bluish green, yellowish at the base, slender, equal, hollow, at first fibrillose, becoming glabrous and polished save at the base; columella dehiscent from gleba in lower half, continuous with stipe, thickened at apex, especially so in ovoid peridia, confluent with the peridium.—Context fleshy.

Spores 12–14–(17) × (6)–7–8.5 (10.8) μ, smooth, sepia in KOH, with a distinct germ pore, with thick complex wall, a continuous pallid exosporium, beneath it a russet-fulvous episporium, and a thick, light-olive honey colored (in KOH) endosporium, with a short central and straight, or more rarely oblique, hilar appendage, not noticeably more different in frontal than in lateral view.

Basidia (14) 18–22 × 5.5–7.7 μ, typically 4-spored, hyaline, varying from subcylindric to bi-ventricose (with a median constriction), sterigmata straight and spine-like. Cystidia none, except for small ampullaceous cystidioles about 22 × 7.5 μ (2.5–2.7 μ diam. at apex), hyaline or with a globose melleous incrustation at apex, frequently seen in sections of the edge region of over-mature tramal plates.

Hymenophoral trama distinctly regular, soon some gelantinization clearly evident, melleous to hyaline in KOH, walls of hyphae up to 1.2 μ thick, hyphal arrangement subparallel; trama of the peridium with an outer pelliele-like layer consisting of narrow (1–2 μ diameter) thin-walled hyphae, loosely arranged and strongly gelatinized; non-gelatinous inner peridial trama consisting of parallel repent hyphae, some with rather strongly swollen cells (to 22 μ diam.), walls to 1.3 μ thick, but not so subcellular as in *W. erythrocephalum;* all hyphae with camp connections.

On the ground or much more commonly on decaying wood, especially rotting branches of *Melicytus ramiflora* in the lowland forests of the North Island of New Zealand, fruiting in early winter and spring, freely eaten by slugs. Extending apparently over an area covering Auckland and Wellington.

Material studied: Weraro, Wellington, Feb. 5, 1923, *J. C. Neill & G. H. Cunningham*, det. G. H. Cunningham, Fungi of New Zealand, ex Herb. Cunningham no. 1098 (MICH).

Illustrations: Cunningham (1942) pl. 9, fig. 1; 34 fig. 17.

This species, because of the color of the spores and its gleba and the other correlated microscopical characters corresponds most strikingly to the subfamily *Stropharioideae,* more precisely the genus *Psilocybe.* The cystidioles observed at the free edges of old glebal walls are obviously homologous with the cheilocystidia of the *Psilocybes* and coincide also in shape and appearance.

The description of the macroscopic features is for the most part adapted from Cunningham (1942).

Cunningham has also studied the development of the carpophores, and reported about his interesting observations together with those on *W. erythrocephala* (see that species).

2. **Weraroa erythrocephala** (Tul.) Sing. & Smith, comb. nov. Fig. 3, spores *Secotium erythrocephalum* Tulasne, Ann. Sc. Nat., ser. III 4: 176.

1845, *Secotium lutescens* Lloyd, Letter 19, P. 6, 1908, *nom. nud.* (sec. Cunningham).

Gastrocarp 20–40 mm. tall, and up to 60 mm. in diameter, globose, depressed-globose or ovate and apex obtuse or rounded, truncate-excavate or decurrent at base; peridium ¾–1 mm. thick, scarlet-red when fresh, dried "Nopal red" (R.), or *holly berry* (M & P, 2nd ed.), reminding one of

All figures were drawn with the aid of a camera-lucida from material revived in 2.5% KOH. As reproduced the spores are magnified about 1000 × and the cystidia and basidia about 450 ×. Figs. 1–2. Cystidia and spores of *W. virescens.* Fig. 3. Spores of *W. erythrocephala.* Fig. 4. Basidia, and cystidia of *W. novae-zelandiae.* Fig. 5. Spores of *W. novae-zelandiae.*

dried carpophores of *Hymenogloea,* smooth, glabrous, shining, viscid, frequently dimpled.

Gleba loculate, chambers polygonal or slightly elongate, numerous, up

to 3 mm. long, ferruginous when fresh, between "Antique brown" and "Sudan brown" (R.), or *Sudan br.* (M & P 2nd ed.) when dried, tramal plates 30–75 $\mu$ thick.

Stipe up to 100 mm. long, 3–10 mm. thick, equal, smooth or fibrillose, often polished, hollow, bright yellow; columella confluent with stipe and equal in diameter or slightly narrower but slightly expanded at apex where it joins the upper portion of the peridium; veil present in the angle between the incurved peridium margin and the apex of the stipe—at least in young carpophores, of looser structure than the context.

Context yellow, fleshy, becomes gelatinous in the gleba and outermost layer of peridium.

Spores 12–17.2 × 6.5–9.2[2] $\mu$, ellipsoid to ellipsoid-oblong or more rarely somewhat ovoid, generally axially symmetric with a straight short hilar appendage at the base, apex with a broad germ pore, color (in KOH) deep chestnut in the episporium, but in the exosporium merely pallid, in the endosporium yellowish, color in Melzer's reagent dingy date-brown throughout, some spores with internal ocher-brown granular pigment bodies.

Basidia 15–25 × 5–8 $\mu$ (according to Cunningham); basidioles vesiculose, then clavate; cystidia none seen.

Hymenophoral trama regular, at least partly gelatinized, the portions where the hyphae are densely packed nevertheless easily dissociating under slight pressure in KOH, hyphae subparallel, of variable size (2–7.7 $\mu$ diam.) and hyaline to yellow. Peridial wall formed by concentrically arranged (parallel to surface of peridium), hyphae of relatively short cells (about 54 × 29 $\mu$ or 31 × 22 $\mu$) forming a subcellular layer corresponding to the hypodermium of the agarics, arranged in parallel chains, and covered on the outside of this layer by a conspicuous gelatinous pellicle-like layer of narrower (1–2.8 $\mu$) filamentous hyaline hyphae imbedded in a gelatinous mass. Presence of endocystidia or dermatocystidia not verified by us—no internal bodies in our sections are discernible[3]. Innermost layer of peridium not distinguishable from tramal plates; all hyphae with clamp connections.

On decaying wood in rain forest, one of the most abundant species of "Secotium" in New Zealand, fruiting in spring and fall in Auckland, Wellington, Hawkes Bay, Canterbury, Nelson and Otago, N. Z.

Material studied: York Bay, Wellington, May 17, 1922, *J. B. Cleland*, det, G. H. Cunningham, Fungi of New Zealand, ex Herb. Cunningham, no. 610 (MICH.)—Additional material without indication of locality from Lloyd Herbarium and Massee Herbarium (NY).

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[2] Cunningham (1942) gives a range of 12–25 $\mu$ long; our measurements were from a fully matured specimen identified by Cunningham.

[3] Cunningham (1925) states that the pigmentation of the carpophore begins when the latter is about one quarter grown. He writes, "The first few layers of the hyphae forming the peridium underlying the gelatinous layer become partly filled with granules of some pigment which readily take the haematoxylin stain. They appear to be imbedded in the protoplasm lining the hyphal walls, and become more plentiful as the plant approaches maturity". This pigment formation apparently fails to show in sections of dried material revived in the mounting media we used.

Illustrations: Lloyd, Myc. Not. 1, pl. 26, figs. 1–6; Cunningham (1942) pl. 8, figs. 3; pl. 34, fig. 16, Tulasne (1845), . . .

In our sections the basidia had all collapsed and only basidioles were plentiful.

We have not studied the type, which is preserved at Paris, but the species is so strikingly distinct and both Tulasne's and Cunningham's accounts so convincing that we accept the latter's identification.

Cunningham succeeded in culturing *W. erythrocephala* and obtained fruiting bodies on sterilized leafmold. Obviously, then, the species is not mycorrhizal. In the same paper (1925) Cunningham gave the results of his studies of the development of the carpophores of both this species and *W. novae-zelandiae*. The development as described is very similar in both species. The longevity of the carpophores is rather remarkable. It takes 2–3 months for them to mature and they persist after maturation for at least another month.

Heim (1951) has described the spores in a manner not fully coinciding with ours. He gives them as obscurely angular (subtly octangular) in outline. At best, this must be a rare exception although such a shape as figured by Heim should be expected in a species close to the Strophariaceae where much more angular outlines of the basidiospores are quite common, especially in *Psilocybe*. On the other hand, however, Heim did not observe pigment granules, as we did, in some of the spores.

3. **Weraroa virescens** (Massee ex Cooke) Sing. & Smith comb. nov. *Secotium virescens* Mass. ex Cooke, Grevillea 10: 47. 1890. *Secotium subperbum* Cunningham, Proc. Linn. Soc, N. S. Wales 49: 104. 1924. Figs. 1–2, cystidia & spores.

Gastrocarp 60 mm. tall, up to 40 mm. broad, conic to fusiform, apex acute, pointed, base with margin decurrent and appressed to stipe (as in *Galeropsis*), less frequently truncate-appressed; peridium 0.4–0.5 mm. thick when dry, occasionally (rarely) becoming lacerated and free from the stipe (columella) and exposing the lower part of the gleba, surface azure blue, sage green, or sea green, dried dull green to olivaceous, shining in age, glabrous, often with an asymmetric longitudinal slit or furrow, viscid at maturity, at first pruinose.

Gleba loculate, chambers 2–4 mm. long, laterally compressed, when fresh ferruginous, slightly deeper than "buckthorn brown" (R.), or as *sorrel* (M & P, 2nd ed.) when dried, walls of the tramal plates 25–60 $\mu$ thick.

Stipe up to about $50 \times 12$ mm., equal or subequal, smooth, shining, hollow, bright lemon yellow; columella continuous with the stipe, but tapering upward, again thickened at apex (where it contacts the peridium), below free from the gleba over the lower two thirds of its length, or entirely; veil none.

Context yellow, odor and taste not noted.

Spores $12–15.3 \times 7–9$ $\mu$, smooth, exosporium entire and hyaline, episporium deep chestnut or ferruginous-castaneous, thin, endosporium stramineous, overall color of spores like that of *Agrocybe aegerita*, mostly

axially symmetrical with a central and straight short hilar appendage, ellipsoid, germ pore broad.

Basidia at first about $19 \times 12$ $\mu$ and elongate-vesiculose, later elongating in upper part and then $26–43 \times 7–13$ $\mu$, with a "neck" 4.3–6.5 $\mu$ broad, the "neck" either equal or more frequently slightly thickened towards the apex but never as broad at apex as at the basal ventricosity, hyaline to yellowish, at first with short sterigmata and occasionally one or two extraordinarily elongated ones (up to 17 $\mu$), later becoming regularly 4-spored with more or less equal, straight, subcylindric or narrowly conic sterigmata 4.8–5.5 $\mu$ long; chrysocystidia present but not numerous, $21–26 \times 13–20$ $\mu$, vesiculose or vesiculose-mucronate, with a central amorphous highly refractive body when seen in KOH or $NH_4OH$, wall up to 0.6 $\mu$ thick.

Hymenophoral trama partly of gelatinous tissue, regular. Peridial wall of an outer pellicle-like layer consisting of narrow (1–3.3 $\mu$) strongly gelatinized hyphae which extend parallel to the surface of peridium of mature specimens, in young stages the hyphae not yet gelatinous and numerous chrysocystidia more or less appressed forming an interrupted fragmentary external layer of dermatocystidia ("pilocystidia"), $25–65 \times 8–15$ $\mu$; beneath the outermost layer is found a tramal layer corresponding to the hypodermium of the agarics, consisting of strongly colored non-gelatinized hyphae which run parallel with the surface and each other, formed of short inflated elements, appearing not quite so pseudoparenchymatous as in *W. erythrocephala*, cadmium orange when revived in KOH in parts and bright yellow elsewhere, apparently the pigment dissolving slightly in the mounting medium, with some dingy yellowish brown apparently intracellular pigment in the darkest zone (in KOH), the portion of the peridium bordering on the most peripheral loculi again gelatinized and with thin hyphae. All tissues with clamp connections on the hyphae.

On the ground in rain forests in Auckland, Wellington, Otago, N. Z.

Material studied: Otaki Fork, Wellington, *J. G. Myers*, det. G. H. Cunningham. Fungi of New Zealand, ex Herb. G. H. Cunningham, Feb. 6, 1923, (MICH), as *Secotium superbum*.—Flem Turn, Wellington; T. Kirk 2598, type of *Sec. virescens* (NY).

Illustration: Cunningham (1942), pl. 7, fig. 3, pl. 8, fig. 4, pl. 34, fig. 15.

This species is particularly interesting because of its various forms of chrysocystidia. Its color and shape make it unmistakable among all secotioid forms.

Department of Botany, University of Michigan
Ann Arbor, Michigan

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# THE EFFECTS OF VARIOUS TREATMENTS IN DIFFERENT GENETIC LINES OF EXCISED TOMATO ROOTS GROWN IN CULTURE

ADDISON E. LEE

In terms of the potential usefulness of excised tomato root cultures as tools for the study of growth and development problems, it is important to determine whether or not given genetic lines have a consistent growth pattern and the extent to which this pattern can be modified by different treatments such as changes in the technique of subculture or changes in the culture medium. The writer (Lee 1954a) has shown that the growth patterns of three genetic lines differ in several respects, i.e., the length and rate of growth of the main axis during a given growth period under standard conditions, the emergence time and position on the main axis of the lateral roots, and the presence or absence of secondary lateral roots. In another paper (Lee 1954b) he has demonstrated that these same three lines differed in the growth potential of their main axis meristems. Daily subculture of the meristematic tip permitted survival of one root line for 60 days without death of any roots or diminution in their growth rate. It was thus presumed that they could have been cultured indefinitely. Daily subculture of another root line failed entirely to improve the growth potential of its main axis meristem, while the third one gave intermediate results in response to this treatment. The growth potential of the main axis meristems of all three lines was limited when subcultures were made at two-day intervals or longer.

The purpose of this report is to provide additional evidence of differences among these tomato roots and to consider the effects of different treatments on their growth in culture.

**Materials and methods.** Clones of excised tomato roots designated University of Texas line 151, 103, 154 and the techniques described in the previous papers (Lee 1954a and b) were used. In the first two groups of experiments, roots were grown by alternating a seven-day tip passage with a four-day segment passage. In the remaining group it was convenient to alternate a four-day tip passage with a three-day segment passage. All of the experiments were repeated one or more times to establish whether or not the growth pattern could be duplicated. In all of the experiments reported the reproduceability of the growth pattern has been verified. Unless otherwise indicated all points on the graphs are an average of 20 roots cultured at a given time.

White's medium (1943) with 2% sucrose was used throughout the experiments as the standard medium. In the second group of experiments, growth in this medium was compared with that in media containing 1% and 1.5% sucrose. The indole acetic acid used in the third group of experiments was made up fresh each week, since previous attempts to use a stock solution which had been stored for several weeks failed to give consistent results.

In the last two groups of experiments the roots were carried through six consecutive transfers (a segment and a tip passage) and measurements were made at each transfer.

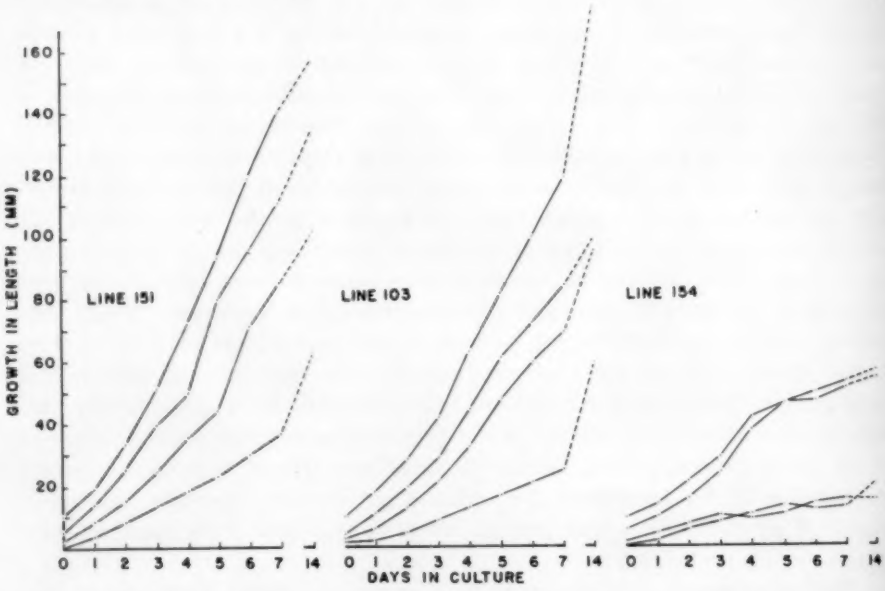


FIG. 1. The growth in length during a 7-day tip passage excised at 1 mm, 2 mm, 5 mm, and 10 mm from the tip. These can be identified by their position on the curves at 0 days on the left of each set of curves. Measurements were made daily. Each point is an average of 10 roots.

**Results and discussion. The culture of tips of different initial lengths.** Ten root tips of each line were excised at a distance of 1 mm, 2 mm, 5 mm, and 10 mm from the tip and grown in culture for a seven-day tip passage. These were measured daily for each of the seven days then transferred to fresh medium and measured again only at the end of another seven-day period. The results are illustrated in figure 1 and demonstrate that for lines 151 and 103 proportionately more total growth can be expected with longer innocula up to 10 mm, the longest utilized in these experiments. Line 154 differed from the others in that there appeared to be little dif-

ference in total growth between groups from 5 mm and 10 mm initial innocula and between those from 1 mm and 2 mm initial innocula. However, the total growth of the 1 mm or 2 mm innocula was considerably less than that of the 5 mm and 10 mm innocula. The results reported here suggest that a considerable proportion of mature tissue is required for the best growth of roots under the conditions of these experiments.

However, it should be noted that Torrey (1954) found that as progressively shorter tips of pea roots were cultured, the constitution of the medium became progressively more important. Torrey modified the medium which he originally used by changing the source of iron, increasing the concentrations of vitamins, and sucrose, and adding several micronutrient elements. Using this modified medium, he was able to culture successfully pea root tips which were initially one-half mm in length. Torrey concludes that the older tissues immediately back of the root meristem serve as a source of vitamin and trace elements which function in the growth of the tip. However, if the tip is otherwise supplied with these necessary substances, it will continue to grow in the absence of the older tissues.

The data indicate that for lines 151 and 103 the rate of growth during the second week drops off considerably for root tips which were initially 2 mm, 5 mm and 10 mm long, while those which were initially 1 mm in length proceed during the second week at a similar rate of growth compared to the first week. However, most of these tips from line 151 and many of those from line 103 were obviously dead or had stopped growth at the end of the second week, while only a few of those initially 2 mm or longer were so affected. Thus one would conclude that for these two lines approximately 2 mm in length would be about the lowest limit in initial size that could be maintained in culture under the conditions of these experiments. In line 154 all tips regardless of their initial length were dead at the end of the second week. Ball (1952) has found that longitudinal excisions through the apical meristem of *Lupinus* will result in the formation of new shoots for each section of the old meristem. He reports that the lowest limit in size of a section from a given meristem which will form a new shoot is approximately one-fifth of the original meristem.

**The effect of sucrose concentration.** Roots were cultured in standard medium containing 1%, 1.5%, and 2% sucrose. The results are illustrated in figure 2. The roots show quite striking differences in their response to different concentrations of sucrose. A concentration of 1% sucrose is clearly better than the other concentrations tried for line 154. On the other hand a 1% concentration of sucrose will support very little growth of line 103. In fact, it was difficult to maintain continued subcultures since many tips were obviously dead at the end of the tip passage. Line 151 could be successfully maintained at any of the levels of sucrose used.

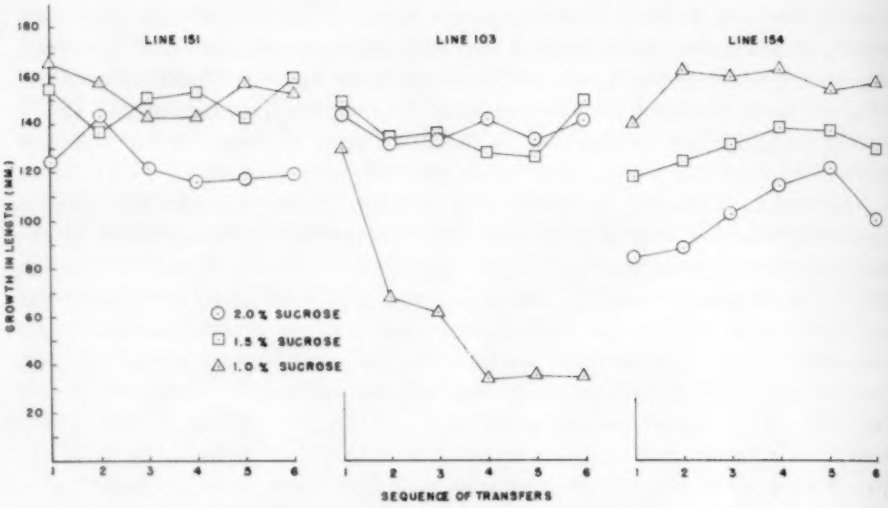


FIG. 2. The growth in length of root tips during six consecutive transfers (4-day segment passage and 7-day tip passage) in media with various concentrations of sucrose. Each point is an average of 20 roots.

Certain differences in the morphology of the roots grown with the several concentrations of sucrose were obvious. These are illustrated in figure 3, where scale diagrams are reproduced of individual roots whose size was close to the numerical average of a given group and whose appearance was typical of that group. As would be expected from the data in figure 2, the most striking responses to different sucrose concentrations were observed in roots of lines 154 and 103. Attention is called particularly to a comparison of line 154 with line 151 when grown in a medium with 2% sucrose. In this medium roots of line 151 looked quite different from

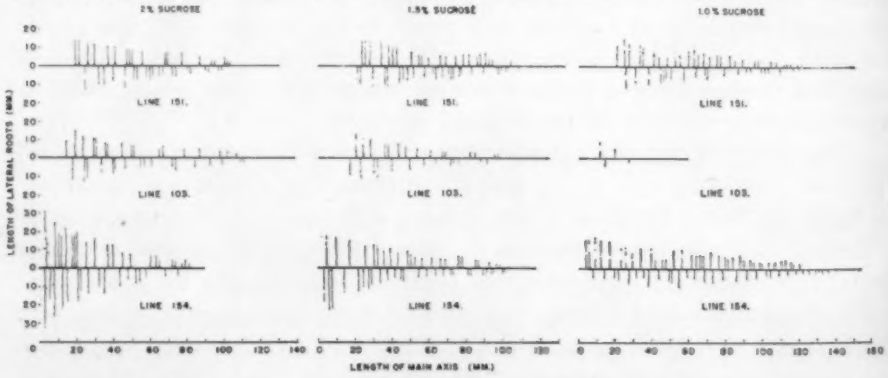


FIG. 3. Scale diagrams of individual roots from the three genetic lines after a 7-day tip passage in medium containing various concentrations of sucrose.

those of line 154. On the other hand, in a medium containing 1% sucrose roots of the two lines were more similar. The overall appearance is quite similar although the roots of line 154 have considerably more lateral roots than those of line 151. Street, McGonagle and Roberts (1953) have shown that the use of 1% sucrose in the culture medium greatly extended the duration of activity of the main axis meristem of their tomato lines as compared to the duration of activity in a medium containing 2% sucrose. Obviously, there are differential effects of various genetic lines in response to different concentrations of sucrose in the culture medium.

**The effects of indole acetic acid.** Roots were cultured in standard medium and in standard medium supplemented with $10^{-10}$ g/l and $10^{-9}$ g/l indole acetic acid (IAA) respectively. The results are illustrated in figure 4 and show some differences among the different lines in their response to

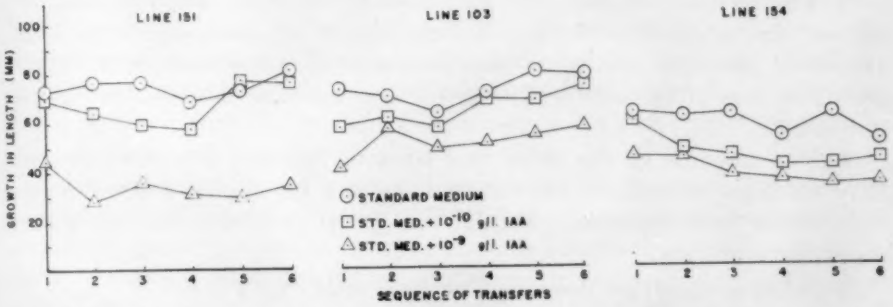


FIG. 4. The growth in length of root tips during six consecutive transfers (3-day segment passage and 4-day tip passage) in media supplemented with various concentrations of IAA. Each point is an average of 20 roots.

IAA. A concentration of $10^{-9}$ g/l inhibits the growth of all three lines but line 151 is much more sensitive to this concentration than the others. In observing the growth pattern of the three lines under standard conditions (medium with 2% sucrose) (fig. 3), one might suppose that the short main axis and long laterals could be due to a fairly high internal concentration of IAA. If this supposition is correct, one would then expect line 154 to react more strongly to an external supply of IAA than the other two lines. The data, however, do not support this conclusion. Von Abrams (1953) found that although tall and dwarf peas responded differently to IAA provided externally, internal differences in auxin inactivation, in diffusion of auxin, or in content of free auxin were not obtained. He concluded that the response of tall and dwarf peas to externally supplied IAA probably was not an indication of the fundamental cause of dwarfism in these plants.

Torrey (1956) has reviewed much of the extensive literature on auxin metabolism in root elongation which involves stimulation, inhibition, and antagonism. It is obvious from the evidence reported that these effects

vary under different conditions and in different plant species, and Torrey concludes that the role of auxin in root elongation has not been clearly established.

SUMMARY

1. The growth in culture of excised root tips of different initial lengths (1 mm, 2 mm, 5 mm, 10 mm) from three different genetic lines was compared. Increasing amounts of mature tissue in the initial innocula were advantageous to growth in culture of two of the three genetic lines. In the third line there was little difference in growth of tips initially 5 or 10 mm in length, however, these grew distinctly more than those initially 1 or 2 mm in length. In this line also all tips were dead at the end of two weeks or earlier. This was also true for tips initially 1 mm long but not for the longer ones from the other two genetic lines.

2. The response of the three root lines to different concentrations of sucrose was quite distinct. A concentration of 1% supported the best growth of one root line while this concentration supported little or no growth to one of the others. The third root line was intermediate in its response.

3. The response of the three root lines to different concentrations of IAA added to the medium was different for each line, but it was not possible to relate these responses to the different growth patterns obtained under standard conditions.

THE DEPARTMENT OF BOTANY, THE UNIVERSITY OF TEXAS
AUSTIN, TEXAS

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# THE STYLOSANTHES BIFLORA COMPLEX

ROBERT H. MOHLENBROCK

The *Stylosanthes biflora* complex is defined as including plant populations not only of *S. biflora* but also of *Stylosanthes riparia* and *Stylosanthes floridana* of other authors. Studies on this complex follow those on *Desmodium* (a genus of the same tribe) by Isely (1953).

Linnaeus (1753) described our *Stylosanthes biflora* under the binomial *Trifolium biflorum*, based on a specimen sent to him from Virginia. In 1788 Swartz described the genus *Stylosanthes* and, one year later, named material sent him from the southeastern United States as *S. elatior*. This epithet was superfluous, however, since it applied to Linnaeus' *Trifolium biflorum*. *Stylosanthes elatior* was widespread in usage for ninety-nine years until Britton, Stern, and Poggenberg made the proper recombination of *Stylosanthes biflora* (L.) BSP. in 1888.

The variability of the species is attested to by the many variants described in the literature. Walter (1788) in his Flora Caroliniana described *S. biflora* under the genus *Arachis*, naming his plant *Arachis aprica*. In 1803 Michaux found specimens with varying degrees of hispidity and named them accordingly—*Stylosanthes hispida* with a moderate number of bristles, *S. hispida* var. *nudiuscula* with few bristles, and *S. hispida* var. *hispidissima* with numerous bristles.

Pursh in 1814 retained Michaux' *S. hispida* but recognized two varieties based on the habit of the plant. These he called *α erecta* and *β procumbens*, the latter actually being the forerunner of the later described *S. riparia* Kearney (1897).

Thomas H. Kearney, exploring in eastern Tennessee (Cocke Co.) along the French Broad River, found nearly glabrous specimens of *Stylosanthes* and named them *S. riparia*. He attributed a further distinction in that the beak of the loment in *S. riparia* was centrally located as opposed to being eccentric as in *S. biflora*. A study of specimens, however, shows that this characteristic does not stand up. Hispid forms (var. *setifera* Fern.) and cream-flowered forms (f. *ochroleuca* Fern.) were described (1938) under *S. riparia*.

Blake in 1920, studying the specimens of *Stylosanthes* at the United States National Herbarium, named a nearly smooth plant with somewhat more inflated loments as *S. floridana*, restricting its distribution to the state of Florida.

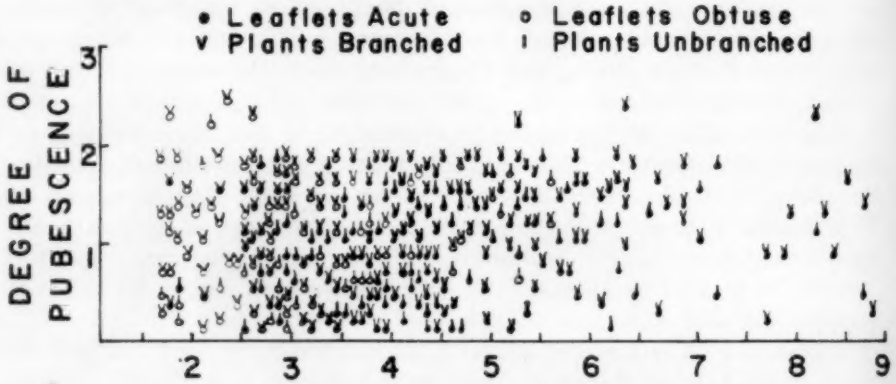
The members of this complex are relatively constant with respect to

loment characters but are diverse in leaflet shape, pubescence, and to some extent habit.

A sharp line of demarcation between these taxa is difficult to determine, a fact which has been noted previously by some workers (Isely 1955).

Three hundred and eight specimens representative of the *Stylosanthes biflora* complex were examined in the present study. Tabulations were made of several variable characters, most of which are used often in classifying the species. These were made on a quantitative or qualitative basis. The characteristics include: (1) length-width proportions of terminal leaflets, (2) shape of leaflet apex, (3) type of bracteal sheath pubescence, (4) type of stem pubescence, (5) branching pattern, (6) loment character.

The length and width of a typical terminal leaflet of a leaf at the node midway between the base of the plant and the inflorescence were determined for each specimen. Leaflet proportions were calculated by determining the ratio length-widths and are tabulated in table 1.




1.

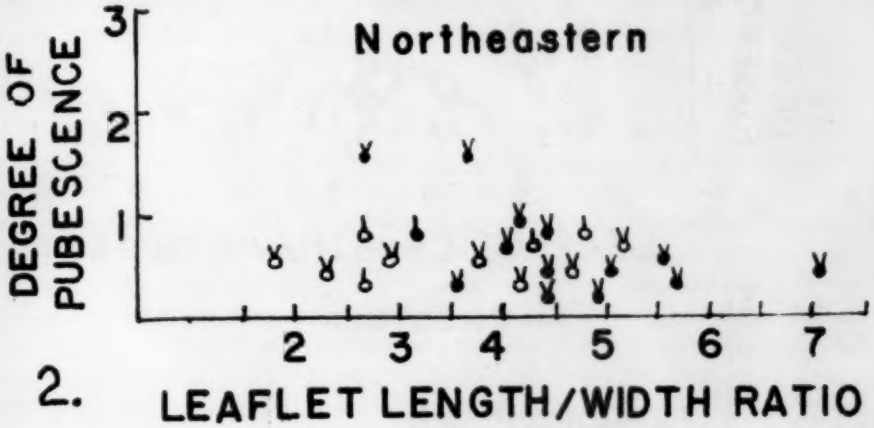
Since degree of pubescence is used as a criterion for the distinction of the taxa included under *Stylosanthes biflora,* an attempt was made to evaluate the characters on a quantitative basis. The scale arrived at was as follows:

| Type of Pubescence | Code No. |
|---|---|
| Bristles on stems and on bracts | 1 |
| Bristles on bracts but lacking on stems | 2 |
| Bristles entirely lacking | 3 |

Specimens belonging to the *S. biflora* complex vary as to their branching pattern and habit. Most of them are without lateral branchlets along the stem; others produce numerous branchlets in a somewhat regular pattern. These latter plants usually assume a sprawling, creeping habit, while the unbranched specimens are most often erect. Leaflet proportions and pubescence are considered simultaneously in figure 1. Also incorporated in

figure 1 are symbols for each specimen designating the branching pattern and the leaflet apex shape.

Specimens studied were found to have leaflets which ranged from 1.7 to 8.5 times longer than broad. The majority had leaflets 2.5–5.5 times longer than broad. All specimens studied which had leaflets over six times longer than broad also had acute apices. Likewise only 90% (45 of 50) of the specimens examined with leaflets less than 2.5 times longer than broad

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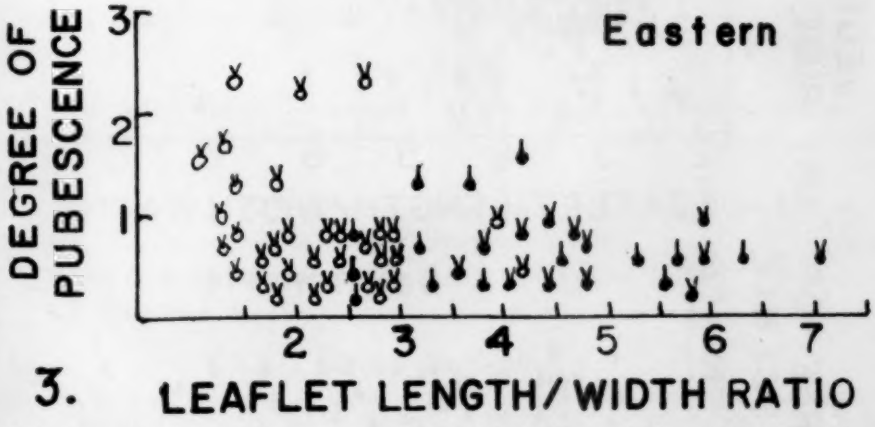
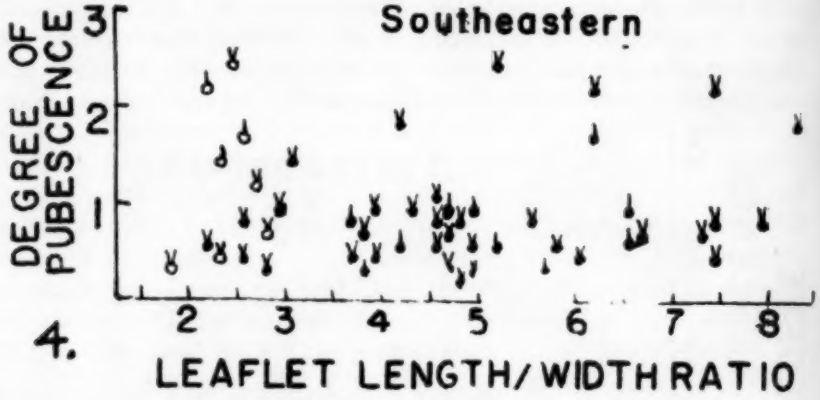



3.

had obtuse leaflets. The pattern of branching is variable with unbranched or branched specimens showing little correlation to any other characters. Specimens with varying degrees of pubescence fell into varying leaflet length-width ratios at seemingly no definite pattern. Loment characters are relatively constant in the *S. biflora* complex. However, some variation may occur in degree of reticulation and in shape with some articulations sometimes more inflated than others. Fruits are generally glabrous but may

be puberulent when immature. Degree of maturity affects these characters of the loment so that in some specimens the entire range of variability may be observed.

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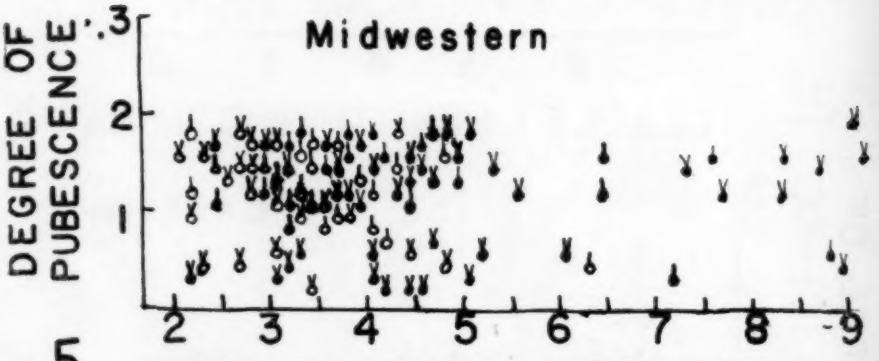


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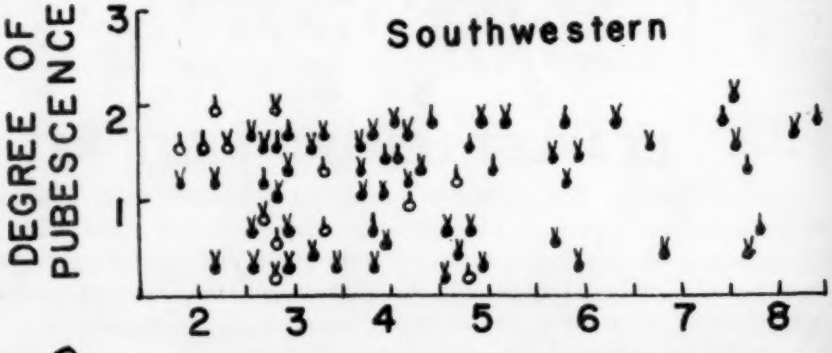


6.

The above data were studied also to see if any geographic correlation could be detected. Scatter diagrams illustrating the characters employed in figure 1 have been prepared for some of the states from which ample collections have been studied (figures 2–6).

The specimens were grouped according to their distribution into five geographic areas. 92% of the Northeastern specimens (Pennsylvania, Maryland, Massachusetts, Delaware, New Jersey) belong to pubescent pattern I, although these specimens are extremely variable in branching pattern, leaflet length-width ratio, and shape of leaflet apices. Specimens from the Eastern United States (West Virginia, Virginia, Tennessee, South Carolina, and North Carolina) are mostly of pubescence pattern I but are nearly evenly divided between having leaflets with acute apices (51%) or obtuse apices (49%). In addition, all latter specimens are branching and tend to have shorter and broader leaflets. Again it is difficult to ascertain a dividing line between populations. Southeastern specimens (Georgia, Alabama, Mississippi, Louisiana, Florida) show a mixing of characters although the few specimens with obtuse leaflets also have shorter and broader leaflets. Pubescence patterns are not correlated with these other conditions. Pubescence type II coupled with long acute leaflets is predominant among the Midwestern (Kentucky, Illinois, Indiana, Missouri, Kansas, Nebraska) and the Southwestern (Arkansas, Texas, Oklahoma) specimens, although enough specimens with type I pubescence and obtuse leaflets occur to make a clear-cut distinction impossible among them.

## SUMMARY

1. The highly variable characters of the *Stylosanthes biflora* complex are so overlapping that no definitive lines of demarcation can separate the specimens adequately.

2. *Stylosanthes riparia* Fern. and *Stylosanthes floridana* Blake are considered synonymous with *S. biflora* (Mohlenbrock 1957).

Department of Botany, Southern Illinois University
Carbondale, Illinois

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# PHOTOPERIODIC RESPONSE OF SOME NEWLY EVOLVED STRAINS OF WHEAT

GADADHAR MISRA

The effects of day length on the growth and maturation of a large number of varieties of wheats grown in different countries under wide differences of climatic conditions have been studied by many investigators, chief of them being Garner & Allard (1923); Adams (1925); Tincker (1929); Arthur, Guthrie & Newell (1930); Hurd-Karrer (1930); McKinney & Sando (1930, 1933) and McKinney (1940). In India, Singh, Kapoor & Choudhri (1938) found the optimal light period to be fifteen hours for variety Pusa 4. Pal & Murty (1941) noted for three English winter wheats that long day following low temperature accelerated earing to a marked extent with plants from unvernalised seeds of Yeoman II. Long days retarded flowering whether given soon after sowing or after an initial period of short days. Kar (1940, 1942–43, 1946 a and b) noted with three varieties of Indian wheats that the post-sowing photoperiodic treatment showed a marked effect on the reproductive phase, irrespective of pre-sowing thermal treatments. Chinoy & Nanda (1946) observed in several cases of Indian wheats that when plants were transferred from a long day to a short day or a normal day, different types of abnormalities, such as branching of ear, elongation of rachis and compounding of lower-most spikelets made their appearance. Nanda & Chinoy (1945) with the same three varieties noted that pollen sterility increases with long as well as short photoperiods.

The present paper is an attempt to throw more light on the photoperiodic behaviour of two mutant strains of wheat under the climatic conditions of Allahabad (Lat 25° 27′ N, Long 81° 44′ E).

**Material and methods.** As a result of exposures, of the pure strains of N.P.52 wheat seedlings, to short waves, eleven mutants R-1, R-2 to R-11 were produced (Ranjan 1940). In subsequent years genetical studies of these new types were undertaken (Ranjan 1946 a). Naithani, Mehrotra & Srivastava (1946) showed that the changes in the number and arrangement of the genes or gene mutation have been responsible for the production of the mutants. Bhattacharya (1943), Ranjan (1946 b) and Ramchander & Bhattacharya (cf. Ranjan 1948) analysed the proteins and mineral contents of these mutants. R-9 was found to have the highest gluten content. Pugh (1945) studied the various mutants in suitably sized plots both under sewage irrigation and also under tube well irrigation. Judging from the point of view of yield and chemical analysis the data from both these experiments indicated that the best all-round wheat is R-9 (Vijaya),

followed by R-1 (Sorojini), R-7, N.P. 52 and R-10. It is worth while noting also that R-1 and R-9 are both awned which is a character generally considered desirable by farmers. The present investigation is designed to test if the photoperiodic response of these two mutants follows the general trend of the other Indian wheats and to note the stage of optimum response to photoperiods in them.

Pure seeds after being graded for uniformity of size were sterilized in 0.2% formalin solution for 3 hours. They were then washed thoroughly in water and were soaked in water for 24 hours. The seeds were sown in

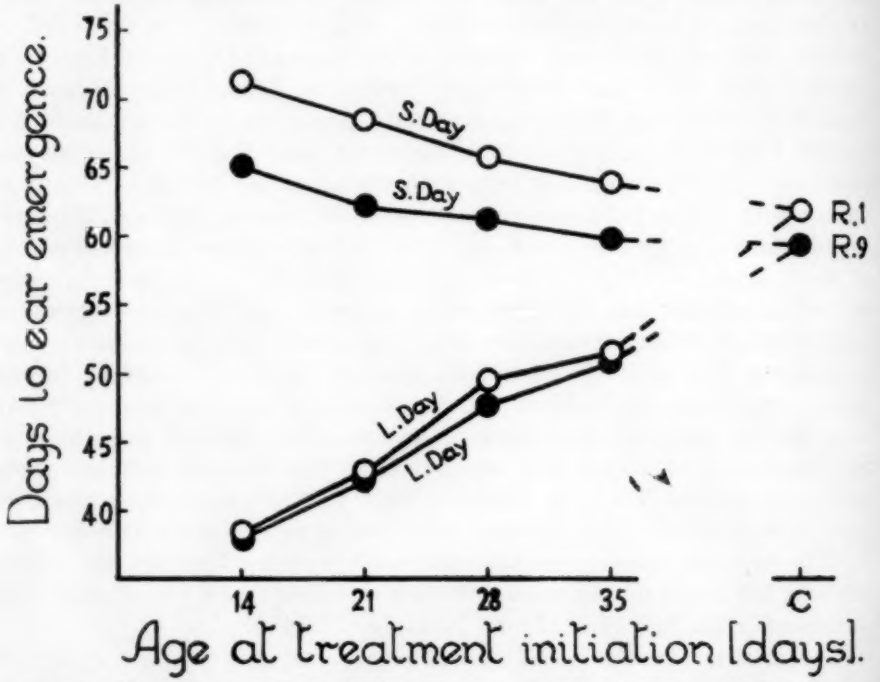


FIG. 1. Time from sowing to heading of the main axis in two mutant wheats, R-1 and R-9, when 24 hr. long days were given to 14, 21, 28 and 35-day-old plants till the time of heading in each case and when 8 hr. short days were given to 14, 21, 28 and 35-day-old plants for one month in each set.

earthenware pots (11″ × 10″) containing well-mixed garden loamy soil and composted manure. The manure was added at the rate of 100 gms per pot. Later on when the seedlings attained the age of 30 days, 1 gm. of ammonium sulphate was added to each pot of the control and the treated sets.

As long-day treatment, a 24-hour continuous photoperiod was used. This was obtained by supplementing the natural day length with artificial illumination from a 1000 watt 'Osram' gas-filled bulb kept at a distance of 5 ft. throughout the night, giving approximately an intensity of 30–40

foot candles at the soil surface of the pot. The long-day treatment was given to seedlings of varying ages of 14–35 days and was continued in each case till ear emergence was complete in the individual pot. As short-day treatment, an 8-hour photoperiod was used. This was obtained by keeping the pots in natural day light daily from 8 A.M. to 4 P.M. and then removing them to a well ventilated light-proof room for the rest of the time. The exposure to short photoperiod in each individual set commenced at different stages of the vegetative phase and was continued in each case for 30 days only after which they were kept outside along with the controls under the natural conditions of day length for the rest of their period of development.

**Results. Experiment (A). Time of heading.** The data on the time of heading of the ears of the main shoot of the individual plants were recorded and are presented in Table 1 and graphically represented in figure 1. The

TABLE 1. *The effect of long and short photoperiods at different ages of the seedlings on heading of the main shoot. Sowing date December 27, 1948. + indicates earliness; – indicates delaying effect.*

| Treatments | No. of days from sowing to ear emergence. (Average of 24 plants) | | | Difference from control in days | | |
|---|---|---|---|---|---|---|
| | R-1 | R-9 | Mean | R-1 | R-9 | Mean |
| Controls | 62.29 | 59.58 | 60.93 | | | |
| L. Day to 14-Day old seedlings | 38.45 | 38.04 | 38.25 | +23.84 | +21.54 | +22.69 |
| 21-Day " " | 42.91 | 42.37 | 42.65 | +19.38 | +17.21 | +18.29 |
| 28-Day " " | 49.62 | 47.79 | 48.71 | +12.67 | +11.79 | +12.23 |
| 35-Day " " | 51.62 | 50.58 | 51.10 | +10.67 | + 9.00 | + 9.83 |
| S. Day to 14-Day old seedlings | 71.20 | 65.12 | 68.16 | – 8.91 | – 5.54 | – 7.22 |
| 21-Day " " | 68.54 | 62.16 | 65.35 | – 6.25 | – 2.58 | – 4.41 |
| 28-Day " " | 65.75 | 61.20 | 63.47 | – 3.46 | – 1.62 | – 2.54 |
| 35-Day " " | 63.95 | 59.79 | 61.87 | – 1.66 | – 0.21 | – 0.93 |

photographs of the treated and control plants are presented in figures 2 and 3.

A study of Table 1 and figure 1 shows that long days during the vegetative phase bring about significant earlier ear emergence in both the strains and that the effect is more pronounced if the long days are applied at the early seedling stage. As the seedlings become older, the long photoperiods produce less and less effect in inducing earliness. Further, the two strains under investigation in common with other Indian wheats previously studied are extreme long-day plants because they flower in continuous light and require no period of darkness. Short days given to 2, 3, and 4 week old seedlings, on the otherhand, bring about delay in ear emergence, the maximum delay being obtained in the case of the youngest i.e., 2-week old seedlings. With 5-week old seedlings the change is not perceptible.

**Tillers, leaves and plant height.** The number of tillers and leaves per

plant as well as the height of the individual plants were recorded at regular intervals during the ontogeny of the plant. The general trend was that tillering was greatly depressed as long as the long-day treatment was operative. Once the treatment was stopped, tillering was augmented and in the final count even surpassed that in the control plants. Short days, on the otherhand, brought about an increase in tillering. The earlier the treatment was begun the greater was the increase in tillering. With regard

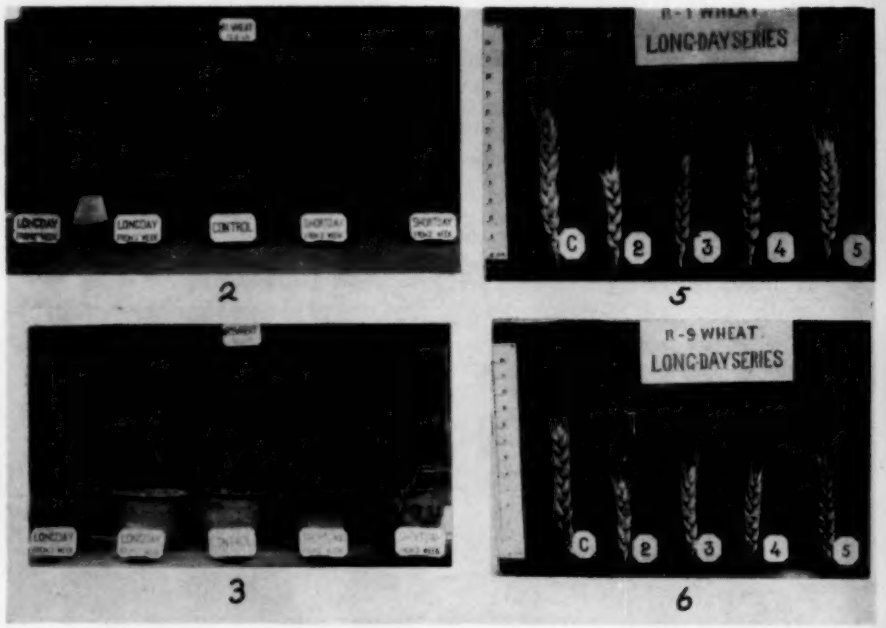


FIG. 2. The wheat plants of variety R-1 which received 24 hr. long days from 2nd and 3rd week headed much earlier than the control plants receiving the full length of day. The plants which received 8 hr. short days from 2nd and 3rd weeks were very much stunted in growth without any stem elongation. Seed sown December 27, 1948. Photographed Feb. 13, 1949. FIG. 3. The wheat plants of the variety R-9 which received exactly the same treatments as above. FIG. 5. Representative ears of the main shoot of wheat plants (R-1) which were exposed to 24 hr. long days at different developmental stages. Numbers beside the ears indicate the age of the plants in week at the time of commencement of the treatment. Control (C) received the full length of day. Photographed after the harvest. FIG. 6. Representative ears of the main shoot of wheat plants (R-9) which received the same treatment as above.

to the production of leaves under the various photoperiods it was seen that there was a clear photoperiodic inhibition during the time when the long-day treatment was being continued while there was an increase in the number of leaves as a result of the short-day treatments. Coming now to the effect of the day length on the elongation of the axis it was observed that under long-day conditions the height of the plants increased rapidly

during the early phase of their life but at the final stage it was much less than that attained by the controls. The plants under the short days, however, developed more or less a rosette type of growth and were greatly stunted. After the treatment was over, elongation of the main axis and tillers took place but generally the treated plants never attained the height of the control plants.

**Grain yield.** The grain yield of the individual plants was recorded as usual and is presented in figure 4.

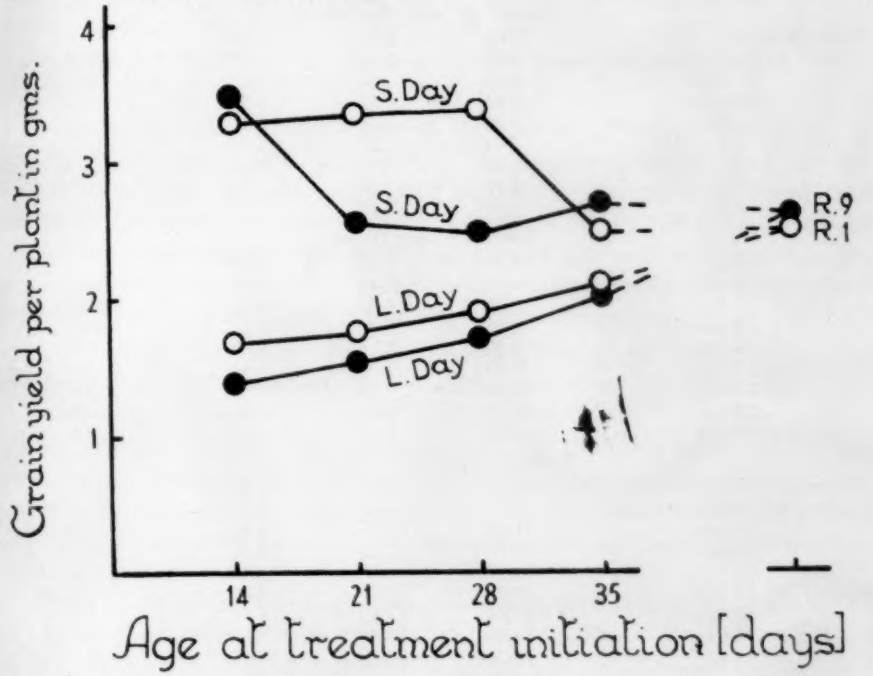


FIG. 4. Grain yield per plant in gms. in the two mutant wheats when 24 hr. long days were given to 14, 21, 28 and 35-day-old plants till the time of heading in each case and when 8 hr. short days were given to 14, 21, 28 and 35-day-old plants for one month in each case.

A study of figure 4 shows that although there has been a significant earliness in ear emergence as a result of the long-day treatments, the grain yield has been considerably reduced. Reduction is greatest when the treatment has been applied to the very young seedlings (2 weeks old). When seedlings of more and more advanced age are treated, the yield gradually increases but at every stage it is much less than the controls. Although there is a trend for increase of grain yield in the short-day treated plants the increase is not statistically significant except at the stage when the treatment is applied to 2-week old seedlings.

**Components of yield.** The components of yield such as the number of ears, length of ear, number of spikelets per ear, number of grains per ear and the one thousand grain weight are presented in Table 2.

TABLE 2. *Components of yield.*

| Treatments | R-1 | R-9 | Mean | Percentage increase (+) or decrease (−) from control |
|---|---|---|---|---|
| *Number of ears per plant* | | | | |
| Controls | 3.00 | 2.91 | 2.95 | |
| L. day to 14-day old seedlings | 3.62 | 3.33 | 3.47 | +17.6 |
| 21-day " " | 4.08 | 3.16 | 3.62 | +22.7 |
| 28-day " " | 3.83 | 3.50 | 3.66 | +24.1 |
| 35-day " " | 3.58 | 3.04 | 3.31 | +12.2 |
| S. day to 14-day " " | 3.41 | 3.37 | 3.39 | +14.9 |
| 21-day " " | 3.66 | 3.20 | 3.43 | +16.3 |
| 28-day " " | 4.12 | 2.95 | 3.54 | +20.0 |
| 35-day " " | 3.75 | 3.04 | 3.39 | +14.9 |
| *Length of ear in cm.* | | | | |
| Controls | 6.90 | 7.15 | 7.02 | |
| L. Day to 14-day old seedlings | 4.58 | 4.38 | 4.48 | −36.2 |
| 21-day " " | 5.00 | 4.30 | 4.65 | −33.8 |
| 28-day " " | 5.00 | 4.96 | 4.98 | −29.1 |
| 35-day " " | 5.70 | 5.35 | 5.52 | −21.4 |
| S. Day to 14-day " " | 7.68 | 7.30 | 7.49 | + 6.6 |
| 21-day " " | 7.33 | 6.58 | 6.95 | − 1.0 |
| 28-day " " | 6.72 | 6.88 | 6.80 | − 3.1 |
| 35-day " " | 6.93 | 6.70 | 6.81 | − 3.0 |
| *Number of spikelets per ear* | | | | |
| Controls | 17.73 | 17.08 | 17.40 | |
| L. Day to 14-day old seedlings | 8.90 | 9.46 | 9.18 | −47.3 |
| 21-day " " | 11.98 | 12.35 | 12.18 | −30.0 |
| 28-day " " | 12.10 | 11.21 | 11.65 | −33.1 |
| 35-day " " | 14.53 | 14.46 | 14.50 | −16.7 |
| S. Day to 14-day " " | 19.63 | 19.58 | 19.60 | +12.6 |
| 21-day " " | 19.50 | 17.85 | 18.67 | + 7.3 |
| 28-day " " | 19.53 | 17.38 | 18.45 | + 6.0 |
| 35-day " " | 18.25 | 16.70 | 17.47 | + 0.4 |
| *Number of grains per ear* | | | | |
| Controls | 25.03 | 28.08 | 26.55 | |
| L. Day to 14-day old seedlings | 16.05 | 15.08 | 15.56 | −41.4 |
| 21-day " " | 14.28 | 17.05 | 15.66 | −41.0 |
| 28-day " " | 18.18 | 16.86 | 17.52 | −34.0 |
| 35-day " " | 22.58 | 20.90 | 21.74 | −18.1 |
| S. Day to 14-day " " | 29.81 | 29.68 | 29.75 | +12.0 |
| 21-day " " | 28.70 | 27.55 | 28.12 | + 5.9 |
| 28-day " " | 26.70 | 27.06 | 26.88 | + 1.2 |
| 35-day " " | 26.36 | 28.38 | 27.37 | + 3.1 |
| *Weight of 1000 grains in gm.* | | | | |
| Controls | 33.10 | 31.96 | 32.53 | |
| L. Day to 14-day old seedlings | 29.15 | 27.50 | 28.32 | −12.9 |
| 21-day " " | 30.03 | 28.75 | 29.39 | − 9.3 |
| 28-day " " | 26.20 | 29.30 | 27.75 | −14.7 |
| 35-day " " | 26.40 | 29.61 | 28.00 | −13.9 |
| S. Day to 14-day " " | 32.31 | 34.50 | 33.40 | + 2.7 |
| 21-day " " | 31.93 | 28.68 | 30.30 | − 6.9 |
| 28-day " " | 30.71 | 31.31 | 31.01 | − 4.7 |
| 35-day " " | 29.53 | 31.90 | 30.71 | − 5.6 |

A study of Table 2 leads to the following salient points:

1. The average number of ears per plant has been considerably increased both under the long-day and short-day treatments. In the long-day set the increase over the controls is significant when the photoperiod has been started with 2, 3, and 4-week old seedlings but in the short-day set the significant increase is found in all ages of seedlings.

2. The average length of the ear has been very much reduced under the long-day treatment. The younger the age of the seedlings at the time of commencement of the treatment the greater is the reduction in length (figs. 5 & 6). Under the short-day treatment there is no material change in the length of the ear.

3. As to the number of spikelets and the number of grains produced per ear, we see the same deleterious effect of the long photoperiods, the greatest reduction is with the commencement of the treatment with 2-week old seedlings and least reduction with 5-week old seedlings. Under short photoperiods there is slight increase in the number of spikelets and grains in the set which received the treatment at the age of 2-weeks while in all other sets there is no appreciable difference from the controls.

4. Grain weight almost uniformly decreases under the long-day lengths irrespective of the age at which the seedlings receive the treatment while it is but little affected by the short-day lengths.

**Experiment (B).** In the experiment of the previous year only a few treatments were included in the test. So in the following year a large number of treatment combinations comprising different cycles of long and short photoperiods and two dates of sowing were tried. In these investigations attention was confined only to the time of heading.

**Time of heading.** The time from sowing to the emergence of the spike in case of the earlier sowing sets is presented in Table 3 and the analysis of variance of the data in Table 4.

A study of Tables 3 and 4 reveals that the different photoperiods exert a profound influence on the flowering time of these two strains of wheats. Long days over a period of 8 days are enough to bring about a significant earliness, the magnitude of which is more the longer the duration of the treatment. In the present studies maximum earliness is effected by 32 days of long days. With regard to the age of the seedlings at which optimum response is found it is clear that seedlings of 8 to 16 days are more effective. Short days, however, produce the reverse effect of delay in ear emergence. Here also a quantitative response is obtained in that greater delay is obtained with longer periods of exposures. The different cycles of long days alternated with short days have resulted in simultaneous blooming of these four sets in both varieties. Such results might be ascribed to the fact that the changes which occur in the plants as a consequence of exposure to favorable photoperiods for a certain duration (a length of time insufficient

to produce flowering) result in some irreversible changes which persist through subsequent durations of exposure to unfavorable photoperiods, so that when the favorable photoperiods are re-established, the process seems to take up where it left off. The results of the year 1949 therefore fully and more extensively confirmed the findings of the previous year.

TABLE 3. *Time from sowing to ear emergence of the main shoot in two varieties of wheats R-1 and R-9. Sowing date, November 22, 1949.*
*+ indicates earliness; − indicates delaying effect.*

| Treatments | Average number of days from sowing to ear emergence | | Difference from controls in days | |
|---|---|---|---|---|
| | R-1 | R-9 | R-1 | R-9 |
| Long-day to 8-day-old seedlings: | | | | |
| 8 days | 69.58 | 62.83 | + 5.67 | + 7.42 |
| 16 days | 58.75 | 59.70 | +16.50 | +10.55 |
| 24 days | 51.62 | 50.58 | +23.63 | +19.67 |
| 32 days | 49.33 | 47.12 | +25.92 | +23.13 |
| Long-day to 16-day-old seedlings: | | | | |
| 8 days | 67.37 | 62.00 | + 7.88 | + 8.25 |
| 16 days | 58.00 | 55.12 | +17.25 | +15.13 |
| 24 days | 53.50 | 52.95 | +21.75 | +17.30 |
| Long-day to 24-day-old seedlings: | | | | |
| 8 days | 68.54 | 63.12 | + 6.71 | + 7.13 |
| 16 days | 61.37 | 61.16 | +13.88 | + 9.09 |
| Long-day to 32-day-old seedlings: | | | | |
| 8 days | 68.00 | 64.58 | + 7.25 | + 5.67 |
| Short-day to 8-day-old seedlings: | | | | |
| 24 days | 88.75 | 83.37 | −13.50 | −13.12 |
| 32 days | 90.54 | 87.54 | −15.29 | −17.29 |
| Long-day to 8-day-old seedlings 24 days followed by 24 short days | 53.75 | 51.58 | +21.50 | +18.67 |
| Short-day to 8-day-old seedlings 24 days followed by 24 long days | 63.20 | 60.70 | +12.05 | + 9.55 |
| 4 cycles of 8 long days alternated with 8 short days beginning with 8-day-old seedlings | 63.12 | 61.33 | +12.13 | + 8.92 |
| 8 cycles of 4 long days alternated with 4 short days beginning with 8-day-old seedlings | 62.25 | 59.37 | +13.00 | +15.88 |
| 16 cycles of 2 long days alternated with 2 short days beginning with 8-day-old seedlings | 62.37 | 60.62 | +12.88 | + 9.63 |
| 32 cycles of 1 long day alternated with 1 short day beginning with 8-day-old seedlings | 61.54 | 58.33 | +13.71 | +11.92 |
| Controls | 75.25 | 70.25 | | |

S.E. of treatment mean = 0.46; C.D. at 5% of treatment mean = 1.27
S.E. of individual mean = 0.64; C.D. at 5% for comparing two individual means = 1.80

The comparison in earliness due to long-day treatments observed in November and January sowings clearly indicates that the after-sowing environmental conditions, daily light period and temperature, are the most essential factors which determined the time of reproduction in these varie-

TABLE 4. *Analysis of variance.*

| *Source of variation* | *D.F.* | *S.S.* | *M.S.* | *F* | *5%F* | *1%F* |
|---|---|---|---|---|---|---|
| Between varieties (V) | 1 | 469.70 | 469.70 | 187.88** | 3.89 | 6.76 |
| Between treatments (T) | 18 | 23705.23 | 1316.96 | 526.78** | 1.66 | 2.03 |
| Interaction (V X T) | 18 | 219.14 | 12.17 | 4.86** | 1.66 | 2.03 |
| Error | 209 | 522.96 | 2.50 | | | |
| Total | 227 | 24917.03 | | | | |

** Significant at 1% level.

ties of wheat. The seeds in the untreated control set when sown in the different months come to ear at markedly different times (Table 5).

**Discussion.** The present study on photoperiodism and vernalisation of two strains of Indian wheat (Misra 1954 a, b) has raised a number of interesting problems which require further experimentation for a fuller understanding. The wheats of the temperate zones have differentiated into two clear-cut groups, winter and spring. There are all gradations from extreme winter types to extreme spring types. The winter types are characterised by the fact that when they are sown in spring they will not head the same cropping year but will continue vegetative growth for an indefinite period. Strictly speaking such distinction does not exist among the Indian varieties of wheats. When sown during any time between October to February they come to flower during the same growing season.

Sexual reproduction in the Indian varieties of wheat does not seem to depend on a critical photoperiod, as this process occurs over very wide ranges of this factor. In the present investigation the mutants flowered when grown under 8–24 hours of day length. In the experiment of Kar (1942–43) flowering took place between day lengths of 6–24 hours. But the time when sexual reproduction takes place is greatly influenced by the photoperiod. The investigations on Indian wheat clearly indicate that irrespective of the pre-sowing condition, the reproductive stage is markedly influenced by post-sowing day lengths. Short days of 6 hours (Kar 1942–43) or 8 hours distinctly prolong the vegetative period while long days of 12 hours (Kar 1942–43), 16 hours (Pal & Murty 1941) or 24 hours (Misra 1949, 1953) curtail the vegetative period. The photoperiod has a profound influence on the morphological and reproductive characteristics of the wheat plant. In the present investigation the long-day plants

TABLE 5. *Time of ear emergence in R-9 wheat when sown on different dates.*

| Date of sowing | Days from sowing to ear emergence of the main shoot |
|---|---|
| November 22 | 70.25 |
| December 27 | 59.58 |
| January 7 | 58.62 |

were much taller at first than the adjacent controls and the short-day plants, but their growth was soon arrested by the early maturation of the heads, leaving the plants abnormally short with reduced leaves and smaller ears. The more slowly developing short-day as well as the control plants grew to twice or thrice the height of the long-day plants beside them and produced fully developed leaves and heads. Besides, when the plants are forced to reproduce rapidly by a longer light period, the production is not more, on the contrary, yield is highly reduced. The plants under the long days are stunted, the leaves small and the heads often sterile. A differential behavior of a similar nature as stated above for the plant under long-day and short-day conditions is observed between Hard Federation, an extreme spring type and Turkey, an extreme winter type when grown under varying day length and temperature conditions (Hurd-Karrer 1933). So far as the short-day treatment is concerned some difference is noted in temperate cereals. Acceleration of flowering by initial short days at a high temperature has been reported in winter wheats by McKinney & Sando (1935) and in winter rye by Purvis (1934) and Purvis & Gregory (1937).

In the present study the earliness of 23–25 days has been brought about in the two varieties R-1 and R-9 by exposure to long photoperiod of 32 days given to 8-day-old seedlings and then followed by normal short days of 10–11 hr. This clearly showed the inductive effect of the long-day photoperiods and was contrary to Eremenko's (cf. Whyte 1939) results in case of strong winter wheats, where no response was found due to prolongation of day length during the first 8–10 or even 15–18 days after vernalisation, after the first developmental phase. He, therefore, concluded that in wheat there exists a biologically important transitional stage between vernalisation (the first phase) and the light phase (the second phase). But in the strains of mutant wheats as well as those studied by Kar (1942–43) the response was noted after 2–3 days of sprouting or immediately after the low temperature thermal phase.

It is now known that the reaction to light treatment of plants varies not only with the variety but also with the age of the plant and at different stages of its life cycle (Borthwick & Parker 1938, Eguchi 1937). In the present investigations it is definitely concluded that the effect of long days in hastening reproduction is maximum with young seedlings of 8–16 days. The effect gradually diminishes with seedlings of advanced age.

## SUMMARY

1. Two strains of x-ray mutant wheats, R-1 and R-9, were subjected to 24 hr. long days and 8 hr. short days at different ages (2, 3, 4 and 5 weeks). In other experimental sets the same photoperiods were given to 8, 16, 24, and 32-day-old seedlings for different durations of 8 to 32 days.

2. Long days in every case brought about a significant shortening in the vegetative period while short days lengthened the same. With regard to the age of the seedlings at which these treatments showed the maximum effectiveness it was noted that more earliness or lateness was seen in the plants which were youngest at the time of commencement of the long-day or short-day treatments respectively.

3. Long-day conditions produced an adverse effect on grain yield consequent upon the production of less number of heads, smaller lengths of the heads, very poor setting and decrease in absolute grain weight. Short-day conditions on the otherhand, produced beneficial effects in some of these characters but resulted in no marked increases in yield.

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Department of Botany, Ravenshaw College,
Cuttack-3. (India)

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# INTROGRESSIVE HYBRIDIZATION IN THE CAREX STANS-BIGELOWII COMPLEX

MAXIMILIAN G. DUMAN AND SISTER DOLORES KRYSZCZUK

The *Carex stans-bigelowii* complex was one of the most difficult groups encountered in the field during the summers of 1938 and 1939 while collecting material for a study of the genus *Carex* in eastern arctic Canada (Duman 1941). In discussing these two species in the same region Polunin (1940) stated, "From my own collections I must cite the following specimens [33 numbers referred to as *Carex* inter *bigelowii* et *aquatilis* var. *stans*] which cannot with certainty be placed either in *Carex bigelowii* or *Carex aquatilis* var. *stans* but fall between these species in the characters that are generally employed for separating them."

These intermediate specimens were later named *Carex* X *nearctica* Raymond (1952). Lepage (1956) discussing this hybrid stated, "Cette plante diffère du *C. stans* par un chaume plus aigu, une bractée inférieure plus étroite et moins lâche á la base, par ses styles plus robustes et plus courts. En cela, elle s'apparente au *C. Bigelowii,* dont que l'inflorescence, par ses feuilles moins basales et de longueur souvent subégale au chaume."

After Anderson's (1949) book on introgressive hybridization appeared our material of these species was re-examined and assigned to a graduate student as a dissertation problem (Kryszczuk 1953). The present paper reconsiders a portion of this unpublished work.

When natural hybrids backcross with one or both of the original parents there is a gradual infiltration of germ plasm of the one species into the germ plasm of the other. Anderson and Hubricht (1938) called this introgression of one species into the other 'introgressive hybridization'. The gene reservoir of this second species now contains genes which it did not develop. This introduction of new genes brings about increased variability in the species concerned. Anderson (1952) advanced "as a working hypothesis, the notion that introgression provides much of the immediate raw material for natural selection." Heslop-Harrison (1956) stated, "From the point of view of the success of the species affected, the mere fact that its store of genetical variation is increased by such a process may add to its ecological potentialities, and therefore be of long-term evolutionary significance."

**Materials and methods.** In 1949 Anderson described his pictorialized scatter diagram, and applied it to a study of introgression in *Iris*. Since that time it has been used in the study of other genera by various workers,

one of the most recent being the study of *Aesculus* populations by Hardin (1957).

In a former paper (Duman 1941) it was pointed out that Mackenzie's (1940) illustration of *Carex bigelowii* Torrey is misleading. Fernald (1942) also found fault with this illustration. It is probably drawn from a specimen modified by introgression. In the same paper (Duman 1941) *Carex stans* Drejer was treated as a variety of *Carex aquatilis* Wahl, a status still given it by some botanists.

Thirty specimens were selected for the present study; ten each were typical of the parent species and ten were intermediate specimens. Of the latter, five had been tentatively identified as *Carex stans* and five as *Carex*

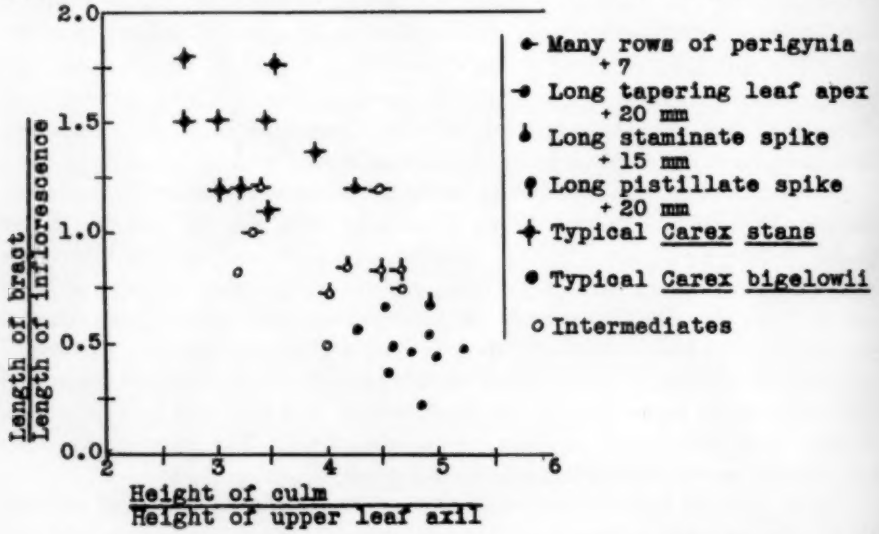


FIG. 1. Pictorialized Scatter Diagram. *Carex stans-bigelowii* Complex.

*bigelowii*. Characters were selected which could be measured directly or given a numerical value. Those varying directly with the size of the specimens were considered unsuitable for primary characters unless they could be used in the form of a ratio.

In setting up the basic scatter diagram the ratio of the bract to the length of the inflorescence was plotted on the y-axis of the graph in fractional subdivisions from 0 to 2, and the ratio of the culm height to the height of the upper leaf axil was plotted on the x-axis in subdivisions from 2 to 6. The ten intermediate specimens were represented by hollow symbols to distinguish them from the solid symbols used for the typical specimens.

Secondary characteristics were represented by protrusions in a definite position on the symbols to show a positive condition. A character was considered positive if its measurement was greater than the mean. To obtain

a numerical value for the 'tapering leaf apex' the leaf was measured from the apex back to a point where the leaf was 2 mm wide.

**Results.** The pictorialized scatter diagram is shown in the figure. The typical *Carex stans* specimens fall in the upper left section, while *Carex bigelowii* specimens fall in the lower right. The intermediate specimens tend to occupy the space between. The positive secondary characters tend to be lost as one approaches the lower right corner, although, as is to be expected, this is far from absolute.

**Discussion.** The number of specimens used in preparing a scatter diagram is necessarily small. Woodson (1947) showed that only relatively few specimens are needed to indicate the trend in variation, and presented evidence that there is no crest of variability in either the roadside or the herbarium profile. He further deplored the neglect of the study of evolution through systematic botany, even though herbarium materials are much more favorable subjects for study than animals.

Anderson (1949) stated that when a pictorialized scatter diagram shows that the secondary characters have a tendency, which is not absolute, to be correlated with the primary characters they must have been introduced together. "The only known mechanism that would explain their tendency to go together, which is far from absolute, is their having been introduced together into the population." He considered that through this technique "it is possible to remove most arguments concerning natural hybridization from the domain of opinion to that of measurement." Hence it would seem that the intermediate specimens used in this study are the result of introgressive hybridization between *Carex stans* and *Carex bigelowii*. It is also suggested that the great variability found in the specimens used as typical *Carex stans* may be the result of introgression.

SUMMARY

1. The end result of introgressive hybridization is the gradual infiltration of germ plasm of one species into the germ plasm of the other, thereby bringing about increased variability in the species concerned.

2. The use of a pictorialized scatter diagram suggests that the variable populations in the *Carex stans-bigelowii* complex studied in northern Canada are due to introgressive hybridization.

Botanical Laboratory, Catholic University
Washington, D.C.
Mary Immaculate Academy
New Britain, Connecticut

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# OBSERVATIONS ON THE RELATION OF MOLDS TO THE EPIDERMIS OF THE FOOT

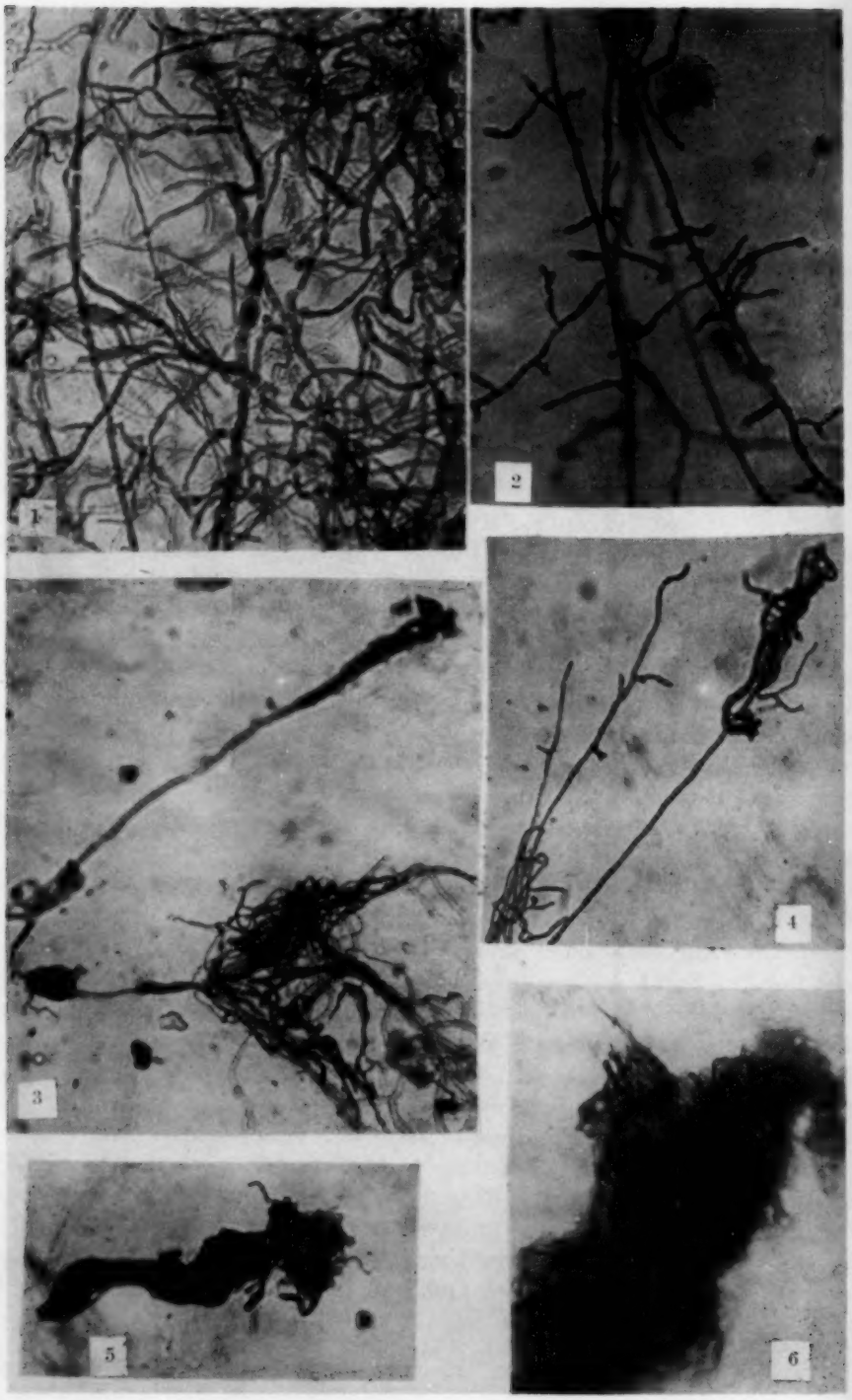
DOROTHY MEIER

Molds are with us constantly, sometimes without our knowledge, at other times living on and in the cells causing minor and occasionally great discomfort. This study is concerned with the relation of molds to the epithelial cells on the side of the foot.

A number of fine texts have been prepared in which are summarized the methods of staining the molds in the host tissue, or of breaking down the host tissue, or clearing it so that the molds may be seen more plainly (Beneke 1957; Conant, Smith, Baker, Callaway. Martin 1955; Lewis, Hopper, Wilson, Plunkett 1957; Skinner, Emmons, Tsuchiya, Henrici 1951). The slides used in this study were prepared by using Amann's fluid (lactophenol coton blue solution). This fluid is ordinarily used for mounting molds for study, but in this case it was used as a mounting fluid for infected skin scales. After a few days, when the slide was dry at the edges of the cover slip, it was sealed with lacquer. At the same time the mounts were prepared, slants of Sabouraud's glucose agar were inoculated with infected tissue. The material looked promising at the time it was prepared. The epithelial cells of the host tissue were stained blue with the cotton blue, and the cell boundaries and the nuclei could be seen plainly where the material was not too thick. Lines suggestive of mold hyphae were interspersed among the cells. After a few days the test tubes showed a growth of *Penicillium*.

No further attention was given to the material for three months, and then the slides were examined again.

In observing these slides prepared three months previously, the author saw that the host's epidermal cells had for the most part disappeared except for occasional isolated cells or small groups of cells. A thin bluish film with granules scattered here and there demarcated the position of the former large masses of tissue. The mold hyphae here were present in great profusion, the material of the cell cavity stained with the cotton blue, the walls remaining clear. The hyphae were of various widths, the cells of different length, leading the author to believe that more than one mold was involved in the infection (fig. 1). This was found to be true when the test tubes inoculated with infected material were observed. Although the top surface of the slants was a mass of green spores, the lower surface showed colony bases of both red and yellow. A transfer of spores from a tube to plates of Sabouraud's agar brought about the growth of three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different molds,—the green spored *Penicillium*, colonies of white fluffy hyphae with numerous microconidia and with a red color at the base, and colonies of a sulphur yellow form with a deep yellow base. The white colony was identified as *Trichophyton rubrum*, the yellow as *Epidermophyton floccosum*.

A detailed study was made of the original slide mount. The hyphae took the form of long straight strands branching at intervals, or formed spirals, or occasionally were in semicircular arrangement as if they had been surrounding cells (fig. 1).

Spores of various types were present although not in great numbers (figs. 1, 2, 3, 4). Figure one shows the presence of a prominent chlamydospore. Microconidia and macroconidia are interpreted to be present in figure 2.

In one place there was a compact, luxuriant growth of the hyphae of *Penicillium* with a conidiophore which was passing through a still undissolved epithelial cell and extending beyond to form sterigmata (fig. 3). In another place where the host tissue had completely dissolved there was seen the mycelium and conidia of *Pullularia* (fig. 4).

In certain regions the epithelial cells were still in the process of breakdown. As their dissolution occurred, the mold hyphae were seen to be packed so compactly and profusely inside the cells that the hyphae expanded beyond the boundaries of the cells as they were released (fig. 5).

As soon as the author realized that dissolution of the epithelial cells infected with molds would take place in time after they had been mounted in Amann's fluid leaving the stained molds, an effort was made to collect skin scales from the same host and repeat the work. A remedy for the eradication of molds had been used meanwhile, but some material was obtained. The mounts were prepared in the same manner as they had been prepared previously, but this time they were studied every few days to record the appearance of the fungi in the host as the epithelial cells were dissolved.

It was observed that the masses of epithelial cells at once stained blue with the cotton blue, but as a week or two passed, the identity of individual cells was lost and globules and granules of material appeared at the edge of the mass as the cells were destroyed. Where tissue particles were small, the cells soon broke up, and in some cases mold filaments were exposed. These mold filaments were often long, and a number of mold filaments

FIGS. 1–6. Photomicrographs of molds that developed in epithelial tissue. Magnification × 250. FIG. 1. Hyphae and chlamydospore. FIG. 2. Microspores and macrospores of *Trichophyton rubrum*. FIG. 3. Mycelium of *Penicillium* with conidiophore passing through host cell and sterigmata. FIG. 4. Mycelium, conidiophores, and conidia of *Pullularia*. FIG. 5. Tightly packed hyphae are released by the gradual dissolution of a host cell. FIG. 6. Hyphae in host cells are revealed as cells disintegrate.

would be seen attached to the outside of a row of host cells. Drops of blue fluid and granules from the dissolved cells adhered to the fungi or were scattered near by.

Individual squamous host cells, and small, thin masses of tissue often appeared to have the cell edges bent over causing a deep crease across the cell surface. As the cells were broken down it was evident that this was no crease, but rather the mold hypha inside the cell that gave the cell added thickness (fig. 6).

*Penicillium* and *Pullularia* are ordinarily considered to be saprophytes. There is a possibility that they were living on dead tissue at the edge of the infection. Both these organisms were found growing from material that fell apart from the larger skin sections.

*Penicillium,* however, has been recorded as a parasite on superficial foot tissue several times (Nencioni 1925, Weidman 1920). There were regions in the larger masses of host tissue where there were structures suggestive of conidiophores and conidia of *Pullularia.* Further observations would have to be made to confirm it as a parasite.

The cause of the skin infection in this case was attributed to *Trichophyton rubrum* and *Epidermophyton floccosum* that lived both inside and outside the epithelial tissues of the host.

The breakdown of the epidermal tissue on the slides is caused by the digestion of the cells by the lactophenol. Where molds were present in great profusion the breakdown was more rapid due to the mold proteinases which had brought about a partial digestion of cells before the mounts were prepared. The lactophenol cotton blue did not destroy the molds because of the wall, which is said to be of chitin, or chitin and cellulose. The cotton blue was absorbed by the mold cell and the material in the cell cavity was stained blue, but the cell wall remained clear.

Preparing mounts of skin tissue infected with molds in Amann's fluid is a simple, easy, but rather slow method of making fine mounts of the molds as they grow in the tissue and in the individual cells. The method of growth, the presence of chlamydospores, microconidia, and macroconidia also may be observed. If the gradual dissolution of the host cells is carefully watched every few days, it is possible to see the relation that existed between the molds and the cells on which they lived.

## SUMMARY

1. The pathogenic molds *Trichophyton rubrum* and *Epidermophyton floccosum,* and the usually saprophytic forms *Penicillium* and *Pullularia* were found growing in and on the cells of a sample of epithelial tissue when thin pieces of the tissue were mounted in Amann's fluid and sealed with lacquer and left for some weeks.

2. The proteinases of the molds caused a partial digestion of the cells, and this was completed gradually over a period of weeks by the lactophenol cotton blue.

3. By watching the dissolution of the epithelial cells it was possible to see that the molds grew either sparsely or profusely in the cells, and that they also grew lengthwise along the exterior of cells.

4. Spore production by conidia was observed by *Pullularia*, and the formation of a conidiophore and sterigmata by *Penicillium* was seen. Microconidia and macroconidia formed by *Trichophyton rubrum* were judged to be present. Chlamydospores were seen plainly.

5. This is a simple and satisfactory, although a slow method of observing the relation between the mold and the epidermal tissues of the host.

BIOLOGY DEPARTMENT, HUNTER COLLEGE OF THE CITY OF NEW YORK
NEW YORK 21, N. Y.

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# TORREYA

## A Partially Annotated Catalogue of Vascular Plants Reported from Island Beach State Park, New Jersey

JOHN A. SMALL AND WILLIAM E. MARTIN

Species included in this list are represented by specimens deposited either in the Local Herbarium of the Academy of Natural Sciences of Philadelphia, the Herbarium of Douglass College at Rutgers (these two collated by the senior author), or in the Chrysler Herbarium at Rutgers State University of New Jersey (deposited by the junior author). Nomenclature and the order of taxa higher than genus are the same as that of Fernald (1950). Binomial and varietal names are listed alphabetically after the appropriate family names. Many of the common names are mere translations of the Latin names and therefore are not recommended. Ecological annotations, supplied by the junior author, are based on field work, 1956 and 1957, and they are restricted to those species with which he is most familiar.

Those wishing to consult other publications pertinent to this area are referred to Knieskern (1857), Harshberger (1901, 1908, 1909, 1910), Stone (1912), Chrysler (1930), and Fender (1938).

### DIVISION PTERIDOPHYTA

### 1. LYCOPODIACEAE

1. LYCOPODIUM ALOPECUROIDES L. Fox-tail Club-moss.
2. LYCOPODIUM CAROLINIANUM L. Carolina Club-moss.
3. LYCOPODIUM OBSCURUM L. Ground Pine: very rare; restricted to Pine Forests.
4. LYCOPODIUM INUNDATUM var. BIGELOVII Tuckerm. Bog Club-moss: Characteristic and common in Cranberry Bogs; locally dominant in a few incipient bogs.

### 2. OPHIOGLOSSACEAE

5. OPHIOGLOSSUM VULGATUM L. Adder's-tongue.

### 3. OSMUNDACEAE

6. OSMUNDA CINNAMOMEA L. Cinnamon Fern: common to locally abundant in bogs, fresh marshes, and wet thickets.
7. OSMUNDA REGALIS L. Royal Fern: same as #6.

### 4. SCHIZAEACEAE

8. SCHIZAEA PUSILLA Pursh. Curly-grass Fern: diligently sought but not found by the junior author.

### 5. POLYPODIACEAE

9. DRYOPTERIS THELYPTERIS (L.) Gray. Marsh Fern: most abundant of all the ferns; common to abundant in most fresh marshes and wet thickets; frequently occurs as pure stands on acid, peaty marshes.
10. ONOCLEA SENSIBILIS L. Sensitive Fern.
11. PTERIDIUM AQUILINUM (L.) Kuhn. Bracken Fern: very rare.

### DIVISION SPERMATOPHYTA
### SUB-DIVISION GYMNOSPERMAE

### 6. PINACEAE

12. CHAMAECYPARIS THYOIDES (L.) BSP. White Cedar: locally common to very abundant as an understory tree in Pine Woodlands; dominant in a few small groves.

13. JUNIPERUS VIRGINIANA L. Red Cedar: the most abundant tree; dominates large areas of Red Cedar Woodland; occurs in all important habitats except active dunes and tidal flats.
14. PINUS ECHINATA Mill. Yellow Pine: rare; occurs with #15.
15. PINUS RIGIDA Mill. Pitch Pine: dominant in Pine Forests which are restricted to a few mesic sites; occasional to rare in other areas.

SUB-DIVISION ANGIOSPERMAE
CLASS MONOCOTYLEDONAE

### 7. TYPHACEAE

16. TYPHA ANGUSTIFOLIA L. Narrow-leaved Cat-tail: occasional to rare; restricted to marshes where it occurs with #17.
17. TYPHA LATIFOLIA L. Common Cat-tail: common to abundant at the edges of fresh or brackish marshes; occasionally as pure stands covering sizable areas.

### 8. ZOSTERACEAE

18. RUPPIA MARITIMA L. Ditch-Grass.
19. ZANNICHELLIA PALUSTRIS L. Horned Pondweed.
20. ZOSTERA MARINA L. Eelgrass: Very abundant in shallow parts of Barnegat Bay, the dead plants washed ashore play an important ecological role.

### 9. GRAMINEAE

21. AGROPYRON REPENS (L.) Beauv. Quackgrass: common but strictly ruderal.
22. AGROSTIS ALBA L. Redtop: common; ruderal and in wet thicket openings.
23. AGROSTIS ALTISSIMA (Walt.) Tuckerm. Tall Bentgrass.
24. AGROSTIS HYEMALIS (Walt.) BSP. Ticklegrass.
25. AGROSTIS PERENNANS (Walt.) Tuckerm. Upland Bentgrass.
26. AIRA CARYOPHYLLEA L. Hairgrass: rare; strictly ruderal.
27. AIRA PRAECOX L. Hairgrass: rare; chiefly ruderal.
28. AMMOPHILA BREVILIGULATA Fern. Dunegrass or Marram Grass: very abundant; dominant on all active dunes except one; abundant in some more mesic sites.
29. ANDROPOGON SCOPARIUS var. LITTORALIS (Nash) Hitchc. Seaside Beardgrass: occasional on low protected dunes and dry, ruderal sites.
30. ANDROPOGON VIRGINICUS var. ABBREVIATUS (Hack) Fern. & Grisc. Bog Beardgrass: restricted to wet sites; occasional in bogs, fresh marshes, and wet thickets.
31. BROMUS COMMUTATUS Schrad. Brome-grass.
32. BROMUS TECTORUM L. Brome-grass: occasional; strictly ruderal.
33. DACTYLIS GLOMERATA L. Orchard Grass: rare; strictly ruderal.
34. DIGITARIA ISCHAEMUM (Schreb.) Muhl. Smooth Crabgrass.
35. DISTICHLIS SPICATA (L.) Greene. Spike-grass: common in island tidal-marshes but lacking from tidal-marshes on the offshore bar.
36. ECHINOCHLOA WALTERI (Pursh) Nash. Salt-marsh Cockspur grass: rare.
37. ERAGROSTIS SPECTABILIS (Pursh) Steud. Tumble-Grass.
38. FESTUCA OVINA L. Sheep's-Fescue.
39. FESTUCA RUBRA L. Red Fescue.
40. HOLCUS LANATUS L. Velvet Grass: rare, ruderal on mesic sites.
41. PANICUM AMARUM Ell. Beach Panic Grass: common on low dunes in association with #186.
42. PANICUM COLUMBIANUM var. ORICOLA (Hitchc. & Chase) Fern. Matting Panic Grass.
43. PANICUM DICHOTOMIFLORUM Michx. Spreading Witch Grass.
44. PANICUM LANUGINOSUM var. FASCICULATUM (Torr.) Fern. Hairy Panic Grass.
45. PANICUM MERIDIONALE Ashe. Panic Grass.
46. PANICUM SPHAEROCARPON Ell. Round-fruited Panic Grass.
47. PANICUM VIRGATUM L. Switchgrass: ruderal or occasionally at the edges of marshes or wet thickets.

48. PASPALUM PSAMMOPHILUM Nash.
49. PHLEUM PRATENSE L. Common Timothy: occasional; strictly ruderal.
50. PHRAGMITES COMMUNIS Trin. Reedgrass: very abundant; characteristic of sand ridges along the bayshore and of tidal-marsh borders.
51. POA COMPRESSA L. Canada Bluegrass.
52. SETARIA GENICULATA (Lam.) Beauv.
53. SPARTINA ALTERNIFLORA Loisel. Salt-water Cord-grass: abundant in all tidal-marshes; and dominant in some; also frequent to abundant in brackish marshes.
54. SPARTINA CYNOSUROIDES (L.) Roth. Salt Reedgrass: occasional on sandy bayshores and on tidal-marsh borders.
55. SPARTINA PATENS (Ait.) Muhl. Salt-meadow Grass: abundant in all tidal-marshes and dominant in some; also dominant in most brackish marshes and present on several low dune sites in association with #28.
56. SPHENOPHOLIS OBTUSATA (Michx.) Scribn.
57. VULPIA OCTOFLORA (Walt.) Rydb. Six-week's Fescue.

## 10. CYPERACEAE

58. CAREX ALATA T. & G. Winged Sedge.
59. CAREX ALBOLUTESCENS Schwein. Whitish-yellow Sedge.
60. CAREX ANNECTENS Bickn. Sedge.
61. CAREX ARGYRANTHA Tuckerm. Silvery-flowered Sedge.
62. CAREX CANESCENS L. Canescent Sedge.
63. CAREX CEPHALANTHA (Bailey) Bickn. Sedge.
64. CAREX EXILIS Dew.
65. CAREX HORMATHODES Fern. Necklace Sedge.
66. CAREX HOWEI Machenz. Howe's Sedge.
67. CAREX KOBOMUGI Ohwi. Japanese Sedge: introduced and superior dune-builder; now established on several sites. (See Small, 1954.)
68. CAREX LANUGINOSA Michx. Wooly Sedge.
69. CAREX SILICEA Olney. Sand Sedge.
70. CLADIUM MARISCOIDES (Muhl.) Torr. Twig-rush.
71. CYPERUS DENTATUS Torr. Toothed Umbrella-sedge.
72. CYPERUS ESCULENTUS L. Yellow Nut-grass.
73. CYPERUS FILICINUS Vahl. Fern-like Umbrella-sedge.
74. CYPERUS GRAYII Torr. Gray's Umbrella-sedge: common on low dunes in association with #183.
75. CYPERUS ODORATUS L. Fragrant Umbrella-sedge.
76. ELEOCHARIS CALVA Torr. Bald Spike-rush: abundant to codominant in many fresh marshes.
77. ELEOCHARIS OLIVACEA Torr. Olive-brown Spike-rush.
78. ELEOCHARIS PARVULA (R. & S.) Link. Spike-rush: very abundant on a few bayshore beaches composed of Eelgrass muck.
79. ELEOCHARIS ROSTELLATA Torr. Small-beaked Spike-rush.
80. ELEOCHARIS TUBERCULOSA (Michx.) R. & S. Large-beaked Spike-rush.
81. RHYNCHOSPORA CAPITELLATA (Michx.) Vahl. Beak-rush.
82. SCIRPUS AMERICANUS Pers. Three-square: common in most fresh marshes; pioneer emergent in some shallow, fresh-water ponds.
83. SCIRPUS PALUDOSUS Nels. Bayonet Grass.
84. SCIRPUS ROBUSTUS Pursh. Salt-marsh Bulrush: rare; restricted to a few brackish marshes.

## 11. XYRIDACEAE

85. XYRIS TORTA Sm. Yellow-eyed Grass.

## 12. COMMELINACEAE

86. TRADESCANTIA OCCIDENTALIS (Britt.) Smyth. Spiderwort: known from one abandoned building site.

### 13. JUNCACEAE

87. JUNCUS ACUMINATUS Michx. Sharp-fruited Rush.
88. JUNCUS BIFLORUS Ell. Grass-leaved Rush.
89. JUNCUS CANADENSIS J. Gay. Canada Rush: common to abundant in most fresh marshes.
90. JUNCUS DICHOTOMUS Ell. Forked Rush.
91. JUNCUS EFFUSUS var. COSTULATUS Fern. Common Coastal Rush: the characteristic Rush of incipient or poorly developed bogs and marshes.
92. JUNCUS GERARDI Loisel. Black Rush: rare; only on salt marsh borders.
93. JUNCUS INFLEXUS L. Rush.
94. JUNCUS MARGINATUS Rostk. Grass-leaved Rush.
95. JUNCUS PLATYPHYLLUS (Weig.) Fern. Flat-leaved Rush.
96. JUNCUS SCIRPOIDES Lam. Rush.
97. JUNCUS TENUIS Willd. Yard Rush: characteristic of moist, compacted paths and little used roads.

### 14. LILIACEAE

98. ALLIUM VINEALE L. Field Garlic: common; strictly ruderal.
99. HEMEROCALLIS FULVA L. Day Lily: known from one abandoned building site.
100. SMILACINA STELLATA (L.) Desf. False Solomon's Seal: locally abundant and predominant in herb strata under certain low thickets and occasional on the backslopes and tops of old dunes.
101. SMILAX GLAUCA Walt. Catbrier: occasional; occurs with #102.
102. SMILAX ROTUNDIFOLIA L. Greenbrier: very abundant; dominant over many large areas; occurs in all important habitats except active dunes and tidal-marshes.
103. XEROPHYLLUM ASPHODELOIDES (L.) Nutt. Turkeybeard.

### 15. IRIDACEAE

104. IRIS VERSICOLOR L. Blue Flag: known from one abandoned building site.
105. SISYRINCHIUM ATLANTICUM Bickn. Blue-eyed Grass: rare; strictly ruderal.

### 16. ORCHIDACEAE

106. CYPRIOPEDIUM ACAULE Ait. Lady's-slipper: very rare.
107. POGONIA OPHIOGLOSSOIDES (L.) Ker. Beard Flower: occasional; apparently restricted to Cranberry Bogs.
108. SPIRANTHES CERNUA (L.) Richard. Common Ladies'-Tresses.

## CLASS DICOTYLEDONEAE
## SUBCLASS ARCHICHLAMYDEAE

### 17. SALICACEAE

109. POPULUS GILEADENSIS Rouleau. Balm of Gilead: abundant in certain parts of the Red Cedar Forest, apparently escaped from cultivation.
110. POPULUS GRANDIDENTATA Michx. Large-toothed Aspen.

### 18. MYRICACEAE

111. MYRICA HETEROPHYLLA Raf. Bayberry; very rare.
112. MYRICA PENSYLVANICA Loisel. Bayberry: very abundant; dominant in many xeric thickets; present in all important habitats except the tidal-marshes.

### 19. CORYLACEAE

113. ALNUS GLUTINOSA (L.) Gaertn. Black Alder: a single tree.
114. ALNUS RUGOSA (Du Roi) Spreng. Smooth Alder.
115. BETULA NIGRA L. River Birch.
116. BETULA POPULIFOLIA Marsh. Grey Birch.

### 20. FAGACEAE

117. QUERCUS ALBA L. White Oak: rare; restricted to edges of Pine Forest or Red Cedar Forest.
118. QUERCUS FALCATA Michx. Spanish Oak: common throughout the arborescent zone and in certain thicket communities; probably at the northern limit of its range on Island Beach.
119. QUERCUS ILICIFOLIA Wang. Scrub Oak: common to abundant throughout the arborescent zone and in certain thicket communities.
120. QUERCUS MARILANDICA Muench. Blackjack Oak: common in Pine Forest; occasional in a few thicket communities.
121. QUERCUS PHELLOS L. Willow Oak: common in a few moist sites along the bayshore; probably at the northern limit of its range on Island Beach.
122. QUERCUS PRINUS L. Chestnut Oak: very rare; represented by a few trees.

### 21. POLYGONACEAE

123. POLYGONELLA ARTICULATA (L.) Meisn. Jointweed: common along the bayshore beach.
124. POLYGONUM PENSYLVANICUM L. Pinkweed: commonly associated with #50.
125. POLYGONUM PUNCTATUM Ell. Dotted Smartweed.
126. POLYGONUM RAMOSISSIMUM Michx. Bushy Knotweed.
127. RUMEX ACETOSELLA L. Sheep Sorrel: common on low dunes and in thicket openings; frequently ruderal.
128. RUMEX CRISPUS L. Yellow Dock: rare; strictly ruderal.

### 22. CHENOPODIACEAE

129. ATRIPLEX PATULA var. HASTATA (L.) Gray. Orach.
130. BASSIA HIRSUTA (L.) Aschers.
131. CHENOPODIUM ALBUM L. Lamb's Quarters: very rare; strictly ruderal.
132. CHENOPODIUM AMBROSIOIDES var. ANTHELMINTICUM (L.) Gray. Wormseed.
133. SALICORNIA EUROPAEA L. Samphire: common in all tidal-marshes.
134. SALICORNIA VIRGINICA L. Perennial Saltwort: predominant species in large areas of tidal-marsh; infrequent in "typical" tidal-marsh.
135. SALSOLA KALI L. Prickly Saltwort: occasional in most tidal-marshes, and on Eelgrass flats and beaches.

### 23. AMARANTHACEAE

136. ACNIDIA CANNABINA L. Salt-marsh Water-hemp.

### 24. PHYTOLACCACEAE

137. PHYTOLACCA AMERICANA L. Pokeweed: occasional; strictly ruderal.

### 25. AIZOACEAE

138. MOLLUGO VERTICILLATA L. Carpetweed: frequent along paths and occasional on low dunes.

### 26. CARYOPHYLLACEAE

139. CERASTIUM VULGATUM L. Chickweed: rare; ruderal.
140. ARENARIA PEPLOIDES L. Seabeach Sandwort.
141. LYCHNIS ALBA Mill. White Campion: rare; ruderal.
142. SCLERANTHUS ANNUUS L. Knawel: rare; ruderal.

### 27. MAGNOLIACEAE

143. LIRIODENDRON TULIPIFERA L. Tulip Tree: probably a single tree.

## 28. LAURACEAE

144. Sassafras albidum (Nutt.) Nees. Sassafras: abundant in most high thickets and in parts of the Red Cedar Forest.

## 29. CRUCIFEREAE

145. Cakile edentula (Bigel.) Hook. Sea Rocket: commonly restricted to beaches and active dunes and associated with #28.
146. Lepidium virginicum L. Peppergrass: occasional; ruderal.

## 30. DROSERACEAE

147. Drosera filiformis Raf. Thread-leaved Sundew: known from three bog sites.
148. Drosera intermedia Hayne. Sundew.
149. Drosera rotundifolia L. Round-leaved Sundew: common under White Cedar (#12) and in Cranberry Bogs.

## 31. CRASSULACEAE

150. Sedum acre L. Stonecrop: known from one ruderal site.

## 32. ROSACEAE

151. Amelanchier canadensis (L.) Medic. Shad Bush: common to abundant in all high thickets and forests.
152. Potentilla simplex Michx. Fivefinger Cinquefoil: rare; ruderal.
153. Potentilla recta L. Sulfur Cinquefoil: rare; ruderal.
154. Prunus serotina Ehr. Wild Black Cherry: common to abundant in most thickets becoming dominant on the landward slopes of some inner dunes and well-stabilized outer dunes.
155. Prunus maritima Wang. Beach Plum: common to abundant on the tops of some inner dunes and on transverse ridges.
156. Pyrus arbutifolia (L.) L.f. Red Chokeberry: occasional to dominant in some marsh thickets; rare on dunes.
157. Pyrus prunifolia Willd. Chinese Apple.
158. Rosa carolina L. Carolina Rose: occasional; ruderal.
159. Rosa rugosa Thunb. Marsh Rose: occasional to dominant in wet or marshy thickets; apparently restricted to wet sites.
160. Rosa virginiana Mill. Pasture Rose: occasional to dominant in xeric thickets; apparently restricted to dry sites.
161. Rubus argutus Link. Blackberry.
162. Rubus flagellaris Willd. Blackberry: frequent; ruderal and in some thickets.

## 33. LEGUMINOSEAE

163. Lathyrus japonicus Willd. Beach Pea: common on backslopes of active dunes and on protected parts of outer backdune areas.
164. Melilotus alba Desr. White Sweet Clover: very rare; ruderal.
165. Robinia pseudo-acacia L. Black Locust: rare; ruderal; apparently escaped from domestic plantings.
166. Strophostyles helvola (L.) Ell. Wild Bean: rare; usually associated with #50.
167. Trifolium arvense L. Rabbit's-foot Clover: rare; ruderal.
168. Trifolium hybridum L. Alsike Clover: rare; ruderal.
169. Trifolium procumbens L. Hop Clover: rare; ruderal.
170. Trifolium repens L. White Clover: rare; ruderal.

## 34. LINACEAE

171. Linum medium (Planch.) Britt. Yellow Flax.

### 35. OXALIDACEAE

172. OXALIS STRICTA L. Wood Sorrel: rare; moist ruderal sites.

### 36. POLYGALACEAE

173. POLYGALA CRUCIATA L. Cross-leaved Milkwort.

### 37. EUPHORBIACEAE

174. EUPHORBIA POLYGONIFOLIA L. Seaside Spurge: common on active dunes in association with #28; rare on inactive dunes in association with #186.

### 38. ANACARDIACEAE

175. RHUS COPALLINA L. Winged Sumac: common to abundant in most protected and mesic thickets; also frequent in forest areas.
176. RHUS RADICANS L. Poison Ivy: very abundant; present and abundant in all except tidal-marsh habitats; extremely variable in growth-form and represented by var. *vulgaris* (Michx.) DC. in most of the more mesic habitats.

### 39. AQUIFOLIACEAE

177. ILEX GLABRA (L.) Gray. Inkberry: frequent but rarely abundant in mesic thickets, at the edges of wet thickets, and at the edges of Cranberry Bogs.
178. ILEX OPACA Ait. American Holly: frequent in xeric thickets but more abundant in mesic thickets and in forest areas.

### 40. ACERACEAE

179. ACER RUBRUM var. TRILOBUM K. Koch. Red Maple: common in mesic thickets and abundant in certain wet thickets; rare on xeric sites.

### 41. VITACEAE

180. PARTHENOCISSUS QUINQUEFOLIA (L.) Planch. Virginia Creeper: occasional to common in most habitats except those which are hydric, brackish, or saline.

### 42. MALVACEAE

181. HIBISCUS PALUSTRIS L. Marsh Mallow: abundant to very abundant, sometimes predominant and rarely absent from fresh marshes; usually present in brackish marshes.
182. KOSTELETZKYA VIRGINICA (L.) Presl. Seashore Mallow: rare; restricted to fresh marshes.

### 43. GUTTIFERAE

183. HYPERICUM BOREALE (Britt.) Bickn. Northern St. John's-wort.
184. HYPERICUM GENTIANOIDES (L.) BSP. Orange-grass: occasional in fresh marshes associated with #183 and in Cranberry Bogs.
185. HYPERICUM VIRGINICUM L. Marsh St. John's-wort: rare to very abundant in fresh marshes; occasionally predominant in limited areas.

### 44. CISTACEAE

186. HUDSONIA TOMENTOSA Nutt. Beach Heather: very abundant on low, inactive dunes; predominant in many areas where it occurs with several, rather constant associates.
187. LECHEA MARITIMA Leggett. Beach Pinweed: occasional to frequent on low dunes in association with #186.

### 45. CACTACEAE

188. OPUNTIA HUMIFUSA Raf. Yellow Prickly Pear: occasional on low dunes usually at the edges of Beach Heather communities.

### 46. ONOGRACEAE

189. Epilobium coloratum Biehler. Purple-leaved Willow-herb.
190. Ludwigia alternifolia L. Seed Box.
191. Oenothera fruticosa L. Evening Primrose: known from one abandoned building site.
192. Oenothera perennis L. Sundrops: frequently ruderal; occasional in fresh marshes and Cranberry Bogs.

### 47. UMBELLIFERAE

193. Daucus carota L. Wild Carrot: very rare; strictly ruderal.
194. Ptilimnium capillaceum (Michx.) Raf. Mock Bishop's-weed.

## Subclass METACHLAMYDEAE

### 48. CLETHRACEAE

195. Clethra alnifolia L. Sweet Pepperbush: occasional in mesic thickets.

### 49. ERICACEAE

196. Arctostaphylos uva-ursi (L.) Spreng. Common Bearberry: known from one site where it is associated with #'s 120 and 186.
197. Chamaedaphne calyculata (L.) Moench. Leather-leaf: known from one small marsh where it grows on the margin of a pond and is associated with #54.
198. Gaylussacia baccata (Wang.) K. Koch. Huckleberry: rare; restricted to Pine Forest.
199. Gaylussacia frondosa (L.) T. & G. Dangleberry: common in Pine Forests especially along the edges.
200. Kalmia angustifolia L. Sheep Laurel: common at the margins of Pine Forests and wet thickets, especially those dominated by #204.
201. Leiophyllum buxifolium (Berg.) Ell. Sand Myrtle.
202. Lyonia mariana (L.) D. Don. Stagger-bush: occasional in association with #'s 175 and 198.
203. Rhododendron viscosum (L.) Torr. Swamp Honeysuckle: rare; wet thickets and Pine Forest.
204. Vaccinium corymbosum L. Highbush Blueberry: very abundant in wet thickets and frequently predominant or dominant.
205. Vaccinium macrocarpon Ait. Large Cranberry: often forming small bogs of distinctive character and regularly present but not abundant in most fresh marsh situations.

### 50. PRIMULACEAE

206. Lysimachia punctata L. Garden Loosestrife: known from one abandoned building site.
207. Samolus parviflorus Raf. Water Pimpernel.

### 51. PLUMBAGINACEAE

208. Limonium carolinianum (Walt.) Britt. Sea-Lavender.

### 52. EBENACEAE

209. Diospyros virginiana L. Persimmon: probably a single tree.

### 53. GENTIANACEAE

210. Bartonia virginica (L.) BSP.
211. Sabatia campanulata (L.) Torr. Marsh Pink.
212. Sabatia stellaris Pursh. Sea Pink: rare; restricted to tidal-marshes.

### 54. ASCLEPIADACEAE

213. ASCLEPIAS INCARNATA L. Swamp Milkweed: predominant in one fresh marsh community.
214. ASCLEPIAS SYRIACA L. Common Milkweed: rare; ruderal.

### 55. CONVOLVULACEAE

215. CONVOLVULUS SEPIUM L. Hedge Bindweed: common along bayshore beaches and in association with #28 or #50.
216. CUSCUTA GRONOVII Wild. Love Vine.

### 56. SOLONACEAE

217. SOLANUM DULCAMERA L. Nightshade: very rare; ruderal.

### 57. SCROPHULARIACEAE

218. GERARDIA PURPUREA L.: known from one abandoned building site.
219. LINARIA CANADENSIS (L.) Dumont. Blue Toadflax: rare; ruderal.
220. VERBASCUM THAPSUS L. Common Mullein.
221. VERONICA OFFICINALIS L. Speedwell: very rare; ruderal.

### 58. BIGNONIACEAE

222. CAMPSIS RADICANS (L.) Seem. Trumpet-Creeper: known from one abandoned building site.

### 59. LENTABULARIACEAE

223. UTRICULARIA INTERMEDIA Hayne. Flat-leaved Bladderwort.
224. UTRICULARIA SUBULATA L. Zig-zag Bladderwort.

### 60. PLANTAGINACEAE

225. PLANTAGO ARISTATA Michx. Bracted Plantain: found on one low dune site.
226. PLANTAGO LANCEOLATA L. English Plantain: rare: ruderal.

### 61. RUBIACEAE

227. CEPHALANTHUS OCCIDENTALIS L. Buttonbush.
228. GALIUM TINCTORIUM L. Marsh Bedstraw.

### 62. CAPRIFOLIACEAE

229. LONICERA JAPONICA Thunb. Japanese Honeysuckle.
230. VIBURNUM DENTATUM L. Southern Arrow-wood: rare; restricted to wet thickets and ruderal sites.

### 63. COMPOSITAE

231. ACHILLEA LANULOSA Nutt. Yarrow: very rare; strictly ruderal.
232. ACHILLEA MILLEFOLIUM L. Yarrow: rare; strictly ruderal.
233. ANTHEMIS ARVENSIS L. Camomile.
234. ARTEMISIA STELLERIANA Bess. Dusty Miller: common and restricted to active dunes; associated with #28.
235. ASTER DUMOSA L. Bushy Aster.
236. ASTER NOVI-BELGII L. New York Aster.
237. ASTER SUBULATUS Michx. Annual Salt-marsh Aster.
238. ASTER TENUIFOLIUS L. Perennial Salt-marsh Aster: rare.
239. ASTER VIMINEUS Lam. Aster.
240. BACCHARIS HALIMIFOLIA L. Sea-Myrtle: abundant in many fresh marshes and frequently predominant or dominant in brackish marshes.

241. BIDENS CONNATA Muhl. Beggar's-Tick.
242. CHRYSANTHEMUM LEUCANTHEMUM L. Daisy: very rare; ruderal.
243. CICHORIUM INTYBUS L. Chicory: very rare; ruderal.
244. CIRSIUM HORRIDULUM Michx. Yellow Thistle: very rare; restricted to bayshore beaches.
245. COREOPSIS GRANDIFLORA Hogg. Tickseed: occasional; ruderal.
246. ERIGERON STRIGOSUS Muhl. Daisy-Fleabane.
247. EUPATORIUM ALBUM L. White Thoroughwort: frequent; ruderal.
248. EUPATORIUM LINEARIFOLIUM Walt. Narrow-leaved Thoroughwort: frequent; ruderal.
249. EUPATORIUM PILOSUM Walt. Woolly Thoroughwort.
250. EUPATORIUM PUBESCENS Muhl. Hairy Thoroughwort.
251. EUPATORIUM ROTUNDIFOLIUM L. Round-leaved Thoroughwort: frequent; ruderal.
252. GNAPHALIUM OBTUSIFOLIUM var. PRAECOX Fern. Catfoot.
253. HELENIUM AUTUMNALE L. Sneezeweed.
254. HELIANTHUS ANGUSTIFOLIUS L. Sunflower: rare; ruderal.
255. HIERACIUM GRONOVII L. Hawkweed: rare; ruderal.
256. HIERACIUM FLORENTINUM All. King Devil: occasional; ruderal.
257. HIERACIUM MARIANUM Willd. Rattlesnake-weed.
258. HYPOCHOERIS RADICATA L. Cat's-ear: occasional along the bayshore beach.
259. IVA FRUTESCENS var. ORARIA (Bart.) Fern. & Grisc. Marsh Elder: common on tidal-marshes and abundant along their inner borders.
260. KRIGIA VIRGINICA (L.) Willd. Dwarf Dandelion: common; ruderal.
261. LACTUCA CANADENSIS L. Canada Lettuce.
262. PLUCHEA CAMPHORATA (L.) DC. Spicy Fleabane: rare; restricted to a few tidal-marsh localities.
263. SOLIDAGO FISTULOSA Mill. Pine Barren Golden-Rod.
264. SOLIDAGO NEMORALIS Ait. Gray Golden-Rod: common in ruderal sites and infrequently in xeric thicket.
265. SOLIDAGO SEMPERVIRENS L. Seaside Golden-Rod: common to abundant on active dunes, on low dunes, and in xeric thickets; predominant in areas of degenerate Dunegrass.
266. SONCHUS ARVENSIS L. Sow Thistle: occasional to common along bayshore beaches.
267. SONCHUS ASPER (L.) Hill. Spiny Sow Thistle.

Rutgers State University of New Jersey
New Brunswick, New Jersey

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## Some Additions to the Flora of Rockland County, New York

Below are listed several species of plants which do not appear in J. Harry Lehr's "An Annotated Preliminary Catalogue of the Vascular Flora of Rockland County, New York," published in recent issues of this BULLETIN. These plants were among 98 specimens collected by the writer on a week-end visit to Orangeburg May 17–18, 1952, and the hills about one mile east of that town. All species were checked by Stanley J. Smith, curator of botany at the New York State Museum in Albany, New York, and specimens have been deposited at the New York State Museum and/or in the writer's personal herbarium. Since Mr. Lehr has not yet completed his studies of *Rubus* and *Antennaria*, species of these genera cannot rightly be considered additions to the Rockland County flora; they are included here simply as a matter of record.

### GRAMINEAE

ALOPECURUS PRATENSIS L. Meadow Foxtail.
POA COMPRESSA L. Canada Bluegrass.

### CYPERACEAE

CAREX BLANDA Dewey. Woodland Sedge.
C. GRACILESCENS Willd. Slender Sedge.
C. LAXIFLORA Lam. Loose-flowered Sedge.
C. RUGOSPERMA Mackenz. "Wrinkle-seeded" Sedge.

### JUNCACEAE

LUZULA ECHINATA (Small) F. J. Herm. "Hedgehog-like" Wood Rush.

### SALICACEAE

POPULUS NIGRA L. Black Poplar.
SALIX RIGIDA Muhl. Heart-leaved Willow.

### RANUNCULACEAE

ACTAEA RUBRA (Ait.) Willd. subsp. RUBRA. Red Baneberry.

### ROSACEAE

PRUNUS VIRGINIANA L. Chokecherry.
RUBUS FLAGELLARIS Willd. Low Running Blackberry.

### UMBELLIFERAE

SANICULA GREGARIA Bickn. Clustered Snakeroot.

### RUBIACEAE

GALIUM LANCEOLATUM (Torr.) Torr. Torrey's Wild Liquorice.

### CAPRIFOLIACEAE

LONICERA XBELLA Zabel. Garden Honeysuckle.

### COMPOSITAE

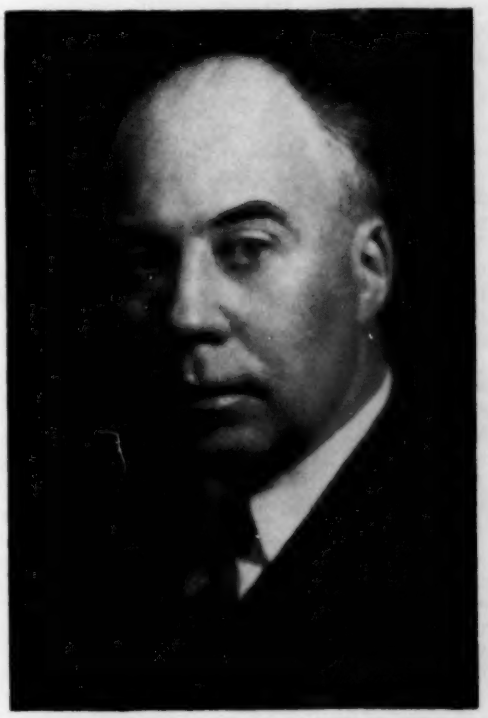
ANTENNARIA FALLAX Greene. "Deceitful" Pussytoes.
A. NEGLECTA Greene. "Overlooked" Pussytoes.
A. NEODIOICA Greene. Smaller Cat's-foot.
A. PLANTAGINIFOLIA (L.) Hook. Plantain-leaved Pussytoes.

KARL L. BROOKS
Brooklyn, New York

## Sam Farlow Trelease

Sam Farlow Trelease was born on July 3, 1892, in the Henry Shaw mansion in the Missouri Botanical Garden, of which his father, William Trelease, was Director. He did his undergraduate work in Washington University in St. Louis, and received his Ph.D. from Johns Hopkins in 1917. From 1917 to 1920 he served as assistant professor and associate professor at the University of the Philippines. He then returned to the staff of Johns Hopkins for three years, and in 1923 went as assistant professor to the University of Louisville. He came to Columbia as associate professor of Botany in 1925, was advanced to a full professorship in 1929, and was named Torrey Professor in 1937. He became Executive Officer of the Department in 1930, a post in which he served until his death on February 1, 1958.

Unlike his father, who was a taxonomist, Professor Trelease began his graduate work in the rapidly expanding field of plant physiology. His early investigations dealt with the growth of plants in balanced salt solutions, the susceptibility of wheat to disease as influenced by salt nutrition and carbohydrate supply, the role of hydrogen ion concentration in physiologically balanced salt solutions, the effect of deuterium oxide on the rate of photosynthesis, and other fundamental aspects of the growth of plants.



Sam Farlow Trelease July 3, 1892–February 1, 1958.

In 1936 Professor Trelease published the first of a long series of articles on the effects of selenium on plants and animals. This toxic element is accumulated by native forage plants, and takes a heavy toll of cattle and sheep on the ranges of fifteen western states, causing alkali disease and blind staggers. Through very careful researches he demonstrated that selenium is required by a few species of plants, especially by certain vetches in the genus *Astragalus*, and that it is stored in quantities that

make these plants highly poisonous to livestock. In the organic form to which it is thus converted, it can be absorbed by various plants, including wheat and other grains. It is therefore important from the standpoint of both animal and human nutrition. At the time of his death, Dr. Trelease was trying to determine the exact chemical form in which selenium occurs in *Astragalus*, with a view to studying the effects of this substance on the growth of various economic plants and domesticated animals. This work on selenium brought him wide recognition. Although he probably was not aware of it, his nickname among the younger botanists of the country was Selenium Sam.

Professor Trelease was the author of three books: "Laboratory Exercises in Agricultural Botany," published in 1919; "How to Write Scientific and Technical Papers," a book which has gone through numerous editions, the last of which appeared in 1958, and which has been widely used—although not widely enough—by students and research workers in all branches of science; and, his magnum opus, "Selenium—its Geological Occurrence and its Biological Effects in Relation to Botany, Chemistry, Agriculture, Nutrition, and Medicine," a scholarly volume written jointly with Dr. O. A. Beath in 1949, dealing with all aspects of this little-known and rare but important element.

Professor Trelease gave the graduate course in Plant Physiology at Columbia for three decades, a graduate seminar in Plant Physiology, and for a shorter time an advanced course in Physiological Plant Pathology. He guided numerous students to the doctorate and beyond. His passing marks the end of an era—the era of the general plant physiologist, able to encompass through broad training, wide reading, and great application, this whole vast field.

Especially in his younger and more vigorous years he gave generously of his time, his counsel, and his unusually well balanced judgement in sundry capacities. He was program editor of the American Association for the Advancement of Science from 1923 to 1930, editor of the American Journal of Botany from 1933 to 1939,—and he changed and modernized its format,—on the Board of Scientific Directors and Board of Managers of the New York Botanical Garden from 1930 until his death, and he served as an officer and on endless committees in the American Association for the Advancement of Science, the Botanical Society of America, and numerous other scientific organizations as well as at Columbia.

Professor Trelease joined the Torrey Botanical Club on February 25, 1925, the year of his appointment to the staff of Columbia University. From that time on he served the Club, generously and faithfully. He was an associate editor from 1926 to 1933, and edited the Bulletin when the Editor was absent on leave during that time. He was an elected member of the Council from 1933, when it was founded, almost continuously to the time of his death. He was Vice-President in 1937, and at various times a member of the Finance Committee, the Budget Committee, and the Membership Committee. Concomitantly Mrs. Trelease was active in the arduous office of Treasurer of the Club from 1927 through 1932.

For a considerable number of years Dr. Trelease was in supervisional charge of the plantings on the Columbia campus. It was during those years that the appearance of the grounds changed completely. He substituted grass for clay and cinders, hedges, flowering shrubs and trees for weeds, and irises for dandelions. Largely through his efforts, Columbia has one of the finest collections of irises to be found anywhere, approximately a hundred different varieties. He astutely realized that of some 350,000 known species of plants, the cultivated varieties of "German" and "Japanese" irises came closest to satisfying the unique Columbia conditions: their flowers are predominantly blue and white, they bloom mostly at the end of May and the beginning of June, they flourish in impoverished soil with little attention, and they are relatively easy to obtain. It was hardly his fault if he was not always successful in having them all burst into bloom simultaneously in the morning of Commencement day, although several times he almost accomplished that feat.

Professor Trelease was a man of exceptionally high standards, who never deviated from his dedication to research. He was in his laboratory and greenhouse every day,

including Sunday, he never took a sabbatical, and he spent every summer in the field collecting seleniferous plants, to be used for analysis in the laboratory. He was singularly fortunate in having Mrs. Trelease as his associate. She not only accompanied him in the field and to the laboratory, but was also co-author of many of his scientific publications.

His published works are not only sound contributions to human knowledge, they are also models of precision and of clarity of presentation. He never had to print a correction, he never had to write a "further contribution" in which he took back what he had previously said. He expected of his students the same criteria of high accomplishment that he imposed upon himself. If at times they chafed, ultimately they all respected and admired him. They still do.

He was a man of quiet but firm determination, with a gentle and unfailing sense of humor. He never sought renown, and he cared nothing for the paths of glory. But through his scientific contributions, which are both fundamental and practical, as well as through the high ideals by which he lived and worked, the world is a little better and a little richer, and so are we.—EDWIN B. MATZKE, Columbia University

**The Published Work of Sam Farlow Trelease**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## Field Trip Reports

**April 20. Inwood Park, New York.** The hundreds of Benzoin (*Lindera*) or spicebush that were in full bloom made the walk of particular pleasure. The group was interested to find cut-leaf toothwort (*Dentaria laciniata*) in bloom but crinkleroot or two-leaved toothwort (*Dentaria diphylla*) was just in bud. There seemed to be a number of stands of these two plants. Dutchman's breeches (*Dicentra cucullaria*) was found blossoming, but it is thought that this wild flower is not growing in such abundance as it was several years ago. Kenilworth ivy (*Cymbalaria muralis*) was found in its accustomed place, covering a considerable portion of a stone foundation and its delicate blossom was admired. It is always a pleasure to rediscover this ivy. Very few birds were sighted. Attendance 17. Leader, Jane Meyer.

**April 26. Greenbrook Sanctuary, Bergen County, New Jersey.** Greenbrook Sanctuary is well described in the 1958 Field Schedule. During its 11 years of existence, over 700 flowering plants have been found growing within its boundaries, but relatively little has been done to determine the cryptogamic flora. In about 1947–48, a list of 59 species of Mosses, Hepatics, Lichens and Myxomycetes was published with no additions since. It is hoped that some of the 40 members of the Torrey Club and the Palisades Nature Association attending will continue to add to the list. Several species of hepatics found fruiting were an introduction to those not familiar with this group. Leader, William Rissanen.

**April 27. Latourette Park, S.I.** The weather was threatening rain all day, but it never really rained. *Tortula muralis* was seen on a number of stone walls. *Equisetum arvense* had both its sterile and fertile fronds up. *Chelidonium majus* L. was found in bloom. Near the ruins of a mill was a small stand of *Caltha palustris*, the only present known stand on S.I. *Erythronium americanum* and *Claytonia virginiana* grew profusely in a wet woodland. Many ferns put in their first appearance: *Onoclea sensibilis, Dennstaedtia punctilobula, Osmunda regalis, O. Claytoniana, O. cinnamonea, Dryopteris noveboracensis, Athyrium felix-femina* and *Pteridium aquilinum*. Attendance 5. Leader, Mathilde P. Weingartner.

**April 27. Island Beach State Park, Ocean County, New Jersey.** Our objective was to see shadbush in flower but we were a few days too early for the best display. Shadbush is a rather consistent component of the tall thickets on mesic to moist sites in the park. Its habit of flowering early and profusely makes it a delightful show, about the first one, of the spring. Buds were well expanded so we could spot the plants readily. *Amelanchier canadensis* appears to be the species present.—Attendance 18. Leader, J. A. Small.

**May 18. Green Engineering Camp, Ringwood, N. J.** The principal part of the field trip was actually conducted in the hilly vicinity of Lake Erskine, Wanaque, Passaic Co., N. J. There were a dozen members and guests, guided by Mrs. Raymond Dowden of Cooper Union Art School and Dr. Ellis Blade, Director of the Camp. We did not confine our efforts to plants alone. Mr. Benjamin Gilberg led us in bird study. The morning hours were particularly rich and varied in bird songs, identified with commentaries by Mr. Gilberg. The very air filled to the brim and overflowed with bird song! One of the most arresting finds was made while returning homeward: several clear well-preserved shell fossils on a slab of rock.

The undersigned led for botany. A stopping-off spot on top of a ledge overlooking Lake Erskine was the most interesting. We could compare two dwarf oaks, scrub and chinquapin (*Quercus ilicifolia* and *Q. prinoides*). There was a large patch of a dwarf cherry, identified as *Prunus susquehanae* in Fernald's Manual. This cherry is called *Prunus pumila* var. *cuneata* (Raf.) Bailey by Gleason, but if truly referring to the same taxon there is a much earlier varietal name, *P. pumila* var. *susquehanae* (Willd.) Jaeger. Clausen regards it as a subspecies of *P. pumila*. Incidentally, the two other varietal combinations, *P. pumila* var. *depressa* and *P. pumila* var. *Besseyi*, should be credited to Bean and Waugh respectively, not to Gleason. The wild azalea (*Rhododendron nudiflorum*) was conspicuous and we repeatedly examined individuals for the glandular flowered form, which we did find quite easily, and that together with leaves

rather softly pilose beneath as well as strigose on the midrib. This fortuitous combination, pubescent leaves and glandular corolla, might mislead, and has misled, by arbitrary use of certain botanical keys, to the identification of the clove-scented *R. roseum*. The leaves of the glandular forms of *R. nudiflorum* examined, however, were never as densely pubescent as those of *R. roseum*, and the ovary was strigose only, not glandular.—Joseph Monachino.

**May 31. Great Kills Marine Park, Staten Island.** For the study of shorebirds but there were not many species of shorebirds in evidence since a great deal of work had been going on right at the crucial time in connection with building a bulkhead, right near our and the birds' favorite peat spit. However, some dowichers, sanderlings, semipalmated sandpipers, ring plovers, black-bellied plovers, and killdeer were observed. Most of the area was filled in land and the plants that come up in such an area forever keep one on the alert. There were blue toad flax and field camomile in bloom. It was too early for the real salt marsh plants to have put in appearance but Ammophila was conspicuously holding the sand of the upper beach. Attendance 23. Leader, Mathilde P. Weingartner.

**June 15. Wards Point, Staten Island.** From Page Avenue and Hyland Boulevard moving south we first noted a stand of persimmon, another of beach plum, and large patches of Tradescantia. Several willow oaks were observed. Deptford pink was seen in flower and water hemlock was about to bloom. Along the beach we observed species of shells and saw where horseshoe crabs had laid thousands of eggs. *Rosa humilis*, one of our wild roses, was in full bloom and very beautiful. *Sisyrinchium angustifolium* was blooming. The white and red mulberries and *Cornus amomum* were found along the way back to the starting point. Attendance 4. Leader, Mathilde Weingartner.

## BOOK REVIEWS

**Flora van Nederland.** By S. J. Ooststroom. 890 pp., including 1038 line drawings. P. Noordhoof N. V., Groningen. 14th Edition. 1956. Price f11.50.

This revised edition of Heukel's "School flora for the Netherlands" has been enlarged to include many new species and some new illustrations. Probably the most distinctive feature of the book is its comprehensive nature, for it includes, in addition to all of the known species of Pteridophytes and Spermatophytes, the many introduced ornamental and crop plants found in the Netherlands. For each species described there is also information as to its growth habits, its distribution, and its flowering or fruiting season. Frequently, also, there are references to the original descriptions.

The author is to be commended for delegating the work of reviewing, and in some cases rewriting, the sections on certain genera or families to qualified experts, 24 of whom are listed in the foreword. The entire book is executed with painstaking attention to details. The excellent glossary should prove useful for beginners.—EDWARD K. VAUGHAN, Oregon State College, Corvallis, Oregon.

**Flora of the British Isles. Illustrations, Part I. Pteridophyta—Papilionaceae.** Drawings by Sybil J. Roles. i–v, 1–144. Cambridge University Press. Cambridge and New York, 21 March 1958. $5.00.

Many popular and semipopular illustrated books are to be had on the British flora. There is only one modern, complete, and taxonomic work known to me: this is the *Flora of the British Isles*, by Clapham, Tutin, and Warburg, published in 1952. The present volume is a companion to that work, bearing the names of the same authors but consisting almost entirely of illustrations. The species represented in this first part are those described in approximately the first third of the *Flora*. (The order of families adopted by these authors is that of Bentham and Hooker rather than the Englerian system of our own current floras and manuals.)

This volume of figures is in a larger format than the *Flora*, doubtless for reasons

of economy in engraving. Librarians will deplore this, since it makes it difficult to shelve the two together; but this is of less importance to the private user. In general there are four species illustrated on each page (a few pages show varieties). Each is represented by a "habit sketch" and a few diagnostic details, such as achenes of *Ranunculus*, siliques of Cruciferae, flowers of *Viola;* almost all drawn from living material. The drawings have not the technical mastery of line and texture of Stella Ross-Craig's well-known series, nor do they show so many details. The authors, indeed, admit in their introduction a somewhat limited function for them, that of conveying mainly the "general appearance" of the species illustrated. Nevertheless they form a useful adjunct to the *Flora* and will be helpful to any one getting acquainted with British plants. They are labeled with English and Latin names, a few of the latter having have been brought up to date. The specimens used are preserved—a highly commendable practice.—H. W. RICKETT.

**Pollen and Spore Morphology/Plant Taxonomy.** Gymnospermae, Pteridophyta, Bryophyta. An Introduction to Palynology II. By Gunnar Erdtman. 151 pages. Illustrated and indexed. Almqvist & Wiksell, Stockholm and The Ronald Press Company, New York, 1957, $8.00.

Anyone familiar with the literature in palynology undoubtedly has come upon the name of Erdtman. More than anyone in this field, he has diligently pioneered his subject, acting as laboratory and field researcher, monographer, and bibliographer. He was trained in the Swedish school of palynology where during the second decade of this century, the significance of pollen and spores in Pleistocene peat first had been realized; Lagerheim and von Post had demonstrated the relationship between pollen stratigraphy and the history of vegetation and climate. His papers are numerous, spanning four decades and treating such aspects of palynology as Pleistocene and pre-Pleistocene pollen stratigraphy, morphology, taxonomy, and the bibliography of pollen literature. Erdtman is perhaps best known for his "Introduction to Pollen Analysis", published in 1943, but also for his serial publications: "Literature on Pollen Statistics" (begun in 1927), "Grana Palynologica" (from 1948), and "Grana Palynologica, Nova Series" (from 1954).

His latest volume is the second in a set of three. Number one, covering the angiosperms, appeared in 1952. The present number two consists mainly of illustrations that follow a two-page introduction and is supplemented by two papers, dealing with microscopy and microtechnique, contributed by separate authors. As Erdtman states in the preface, part two was to include a text as well as illustrations, but since the text was not complete and had to be postponed on account of a trip abroad, it was decided to publish the available illustrations separately. Accordingly, the third volume is to provide the related text.

The separate publication of the illustrations presents an apparent disadvantage. It is frustrating to examine the figures in the absence of descriptive information. And after the appearance of the related text, it will be a nuisance to go from one part to the other in order to find the facts one is seeking. This shortcoming leads one to wish that separate issuance had not been decided. It would seem far better to have postponed publication until both parts could have appeared in a single volume. Be this as it may, one should not labor upon this hindrance, since part two has appeared and should be examined *per se*.

Most of the 253 illustrations are palynograms, carefully drawn from Erdtman's originals by Anna-Lisa Nilsson, who also contributed to part one. Shown are species from over 100 families and approximately 250 genera in different views and exhibiting selected faces, sclerine and exine stratification, and LO-patterns at various magnifications. Some genera (e.g. *Dacrydium, Podocarpus, Isoetes, Lycopodium, Selaginella*) are illustrated by several species. Remaining illustrations are photomicrographs and electron micrographs.

This second part of Erdtman's "Introduction to Palynology" represents another of his valuable tools which is certain to be put to a wide variety of uses on the scientific workbench.—CALVIN J. HEUSSER, American Geographical Society, New York.

**An Introduction to Embryophyta.** By N. S. Parihar. Vol. I. Bryophyta. Second revised edition. Central Book Depot, Allahabad, India. 1957.

This compact volume has been written as an introduction to the study of the Bryophyta. It has been designed primarily for the use of undergraduates in Indian Universities. The fact that this second edition has been issued less than a year after the initial publication, attests to its popularity and usefulness. The information included is largely the result of compilation from the literature, and acknowledgements of sources are given.

An introductory chapter defines the Bryophyta, explains the morphological terms used in the text and includes a discussion of classification. This is followed by a detailed discussion of the structure, reproduction, and development of each of the principal Bryophyte families, complete for both sporophyte and gametophyte stages. A general statement on the distribution and habitat of each family is included. The many drawings illustrating the text include the developmental stages in the growth of reproductive stages for all the families.

The final chapter is a general discussion and summary. The various theories concerning the origin of the gametophyte and the sporophyte are adequately discussed, summarizing the viewpoint of different workers in the field. Our sparse knowledge of the fossil history of the Bryophyta completes the summary. In an appendix the important morphological characters of *Riccia*, *Marchantia*, *Pellia*, *Porella*, *Anthoceros*, *Sphagnum* and *Funaria* are reviewed in tabular form. A glossary of terms is also included here.

This volume is a complete and scholarly treatment of the Bryophyta and compares favorably with older standard works. Its scope is such that it could be used as a text in any part of the world. The bibliographies found at the end of each chapter are extensive and are universal in their coverage. The book is printed on poor quality paper, and the printing is very unsatisfactory. Many lines are unevenly imprinted and some are not straight. The drawings also are badly printed, which is really unfortunate, considering the care and work that probably went into their preparation. The book certainly fills a need for a complete text on the Bryophytes alone.—E. T. MOUL, Botany Department, Rutgers State University, New Brunswick, N. J.

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# INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITOR OF BRITTONIA

## TAXONOMY, PHYLOGENY AND FLORISTICS

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(See also under Spermatophytes: **Breitung**)

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